TO OCE 21 MAY'81

ENVIRONMENTAL IMPACT REPORT

OPEN WATER DISPOSAL OF DREDGED MATERIAL IN LONG ISLAND SOUND, BLOCK ISLAND SOUND AND ADJACENT WATERS

DRAFT

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT FOR THE DISPOSAL OF DREDGED MATERIAL IN THE LONG ISLAND SOUND REGION

APPENDIX A

1981

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

New England Division

ENVIRONMENTAL IMPACT REPORT

OPEN-WATER DISPOSAL OF DREDGED MATERIAL IN

LONG ISLAND SOUND, BLOCK ISLAND SOUND

AND ADJACENT WATERS

Prepared by

Dames & Moore

for

Department of the Army

New England Division Corps of Engineers

424 Trapelo Road

Waltham, Massachusetts 02154

Mr. William F. Lawless, Project Manager

Operations Division

617-894-2400

Under Contract No. DACW33-79-C-0022

March 28, 1980

ABSTRACT

Long Island Sound, Block Island Sound, and adjacent waters extending to the Continental Shelf were systematically studied to identify suitable open water disposal sites for dredged materials. EPA Ocean Dumping Regulations, the issues identified during public scoping meetings, the feelings of members of user groups and organizations, political leaders, and other representatives of the public, and the input of a number of federal, state, and interstate agencies were combined in a site selection process that resulted in the identification of five site areas. These five site areas were deemed suitable for open water disposal of dredged material on the basis of both environmental (such as marine ecology, water quality, fisheries, and similar factors) and social (such as economics, related industries, effects on shipping) factors.

In addition to the five site areas, the present New London and New Haven disposal sites were included in the impact evaluation to provide a comparison between them and newly selected site areas.

In general, if the management recommendations are followed, disposal of dredged materials at these seven sites will result in little to no significant impacts and may in certain cases be managed to improve habitat for beneficial species.

Management recommendations to minimize impacts include analysis of dredged materials to be disposed of (as the disposal areas identified are not equally suitable for all types of dredged material); capping; and management of disposed materials to ensure that materials will be hydraulically, as well as environmentally compatible with the disposal area.

Preface

This document has been prepared in accordance with the guidelines for preparing Environmental Impact Statements published in the Federal Register, Vol. 43, No. 230, November 28, 1978, by the Council on Environmental Quality (CEQ). The use of these guidelines results in a report that is arranged differently from the usual environmental impact statement.

An abstract of this report is a part of the cover sheet; a summary of this report has been prepared as a separate document.

Section I introduces the purpose and background of the study, the regional setting, the laws and regulations affecting dredged material disposal, and the sources and nature of the dredged materials. Section II introduces the sites under consideration and discusses the methods used in selecting them. Section III describes the affected environment and the specific environmental — physical, benthic, and fisheries — characteristics of each of the seven candidate sites. Section IV discusses the environmental consequences, both short- and long-term. Section V describes unavoidable adverse impacts. It also contains a management summary with recommendations of techniques to control, mitigate, or minimize disposal impacts, and a subsection on monitoring and research studies. Section VI discusses the relationship between short-term use of the environment and the maintenance and enhancement of long-term productivity; while Section VII is a discussion of irreversible and irretrievable commitments of resources which would be involved if the project were implemented. Section VIII is a list of preparers.

According to the CEQ, all of the background technical material and the reasoning behind the judgment made should appear in such sections as Environmental Consequences (IV), with references to appropriate appendices. For this reason, the backgrounds for judgments or evaluations made in the earlier sections (which are intended to be in a sense summaries of the data and conclusions) do not necessarily appear in those chapters but are discussed in detail in such subsections as III.A and Sections IV through VII.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

I. INTRODUCTION

I.A Purpose and Background of the Study

I.A.1 Purpose

The purpose of this Environmental Impact Report (EIR) is to assess the impacts associated with open water disposal of dredged materials from the Long Island Sound Region. The geographic area evaluated included Long Island Sound, Block Island Sound and contiguous ocean waters (Figure I.A-1). This effort is composed of three major elements:

- Identification of the most environmentally suitable site or sites for open water disposal.
- The assessment of environmental impacts at the candidate sites.
- The identification of mitigative measures that can be used in a management plan to reduce the environmental impacts identified.

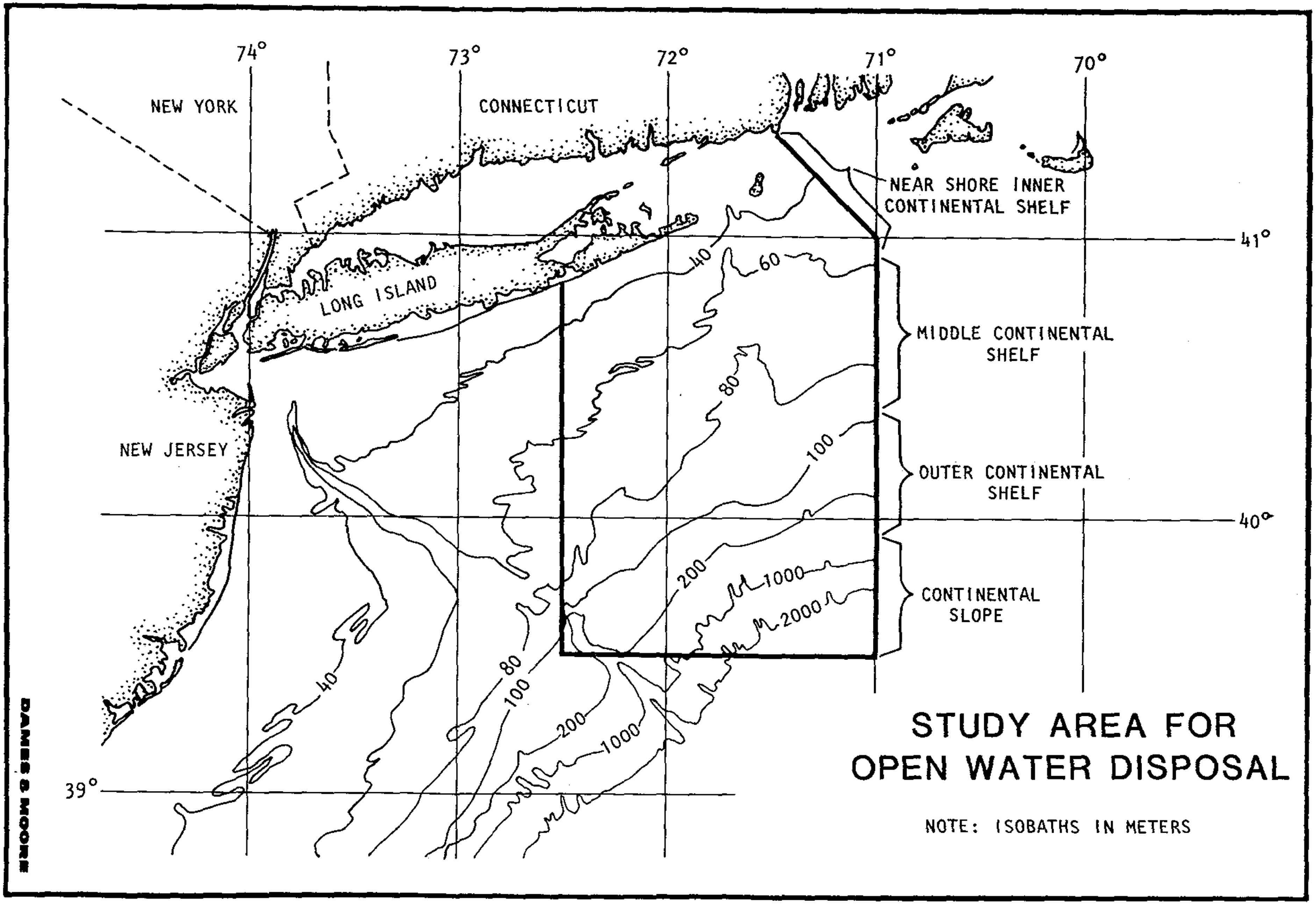
The site selection analysis and identification of candidate sites are discussed in Section II. The pertinent characteristics of the seven candidate sites are presented in Section III; impact assessments and a comparative summary of candidate site impacts are presented in Section IV. Mitigative measures are presented in Section V, together with recommendations and conclusions.

This EIR is to serve as part of the base information for a Composite Environmental Impact Statement (CEIS) and an overall Dredging Management Plan (DMP) to be prepared by the Corps of Engineers, New England Division, for dredging and the deposition of dredged materials for the total geographic region of Long Island Sound. The CEIS and DMP will address the deposition of dredged materials on land, habitat development, island creation, productive uses, and other alternatives. The EIR thus provides the basis for considering the open water disposal alternative.

The Corps of Engineers, New York District, is also conducting a comprehensive evaluation of disposal of dredged material from New York harbor. One volume of this study has been referenced (Conner et al., 1979).

I.A.2 Background

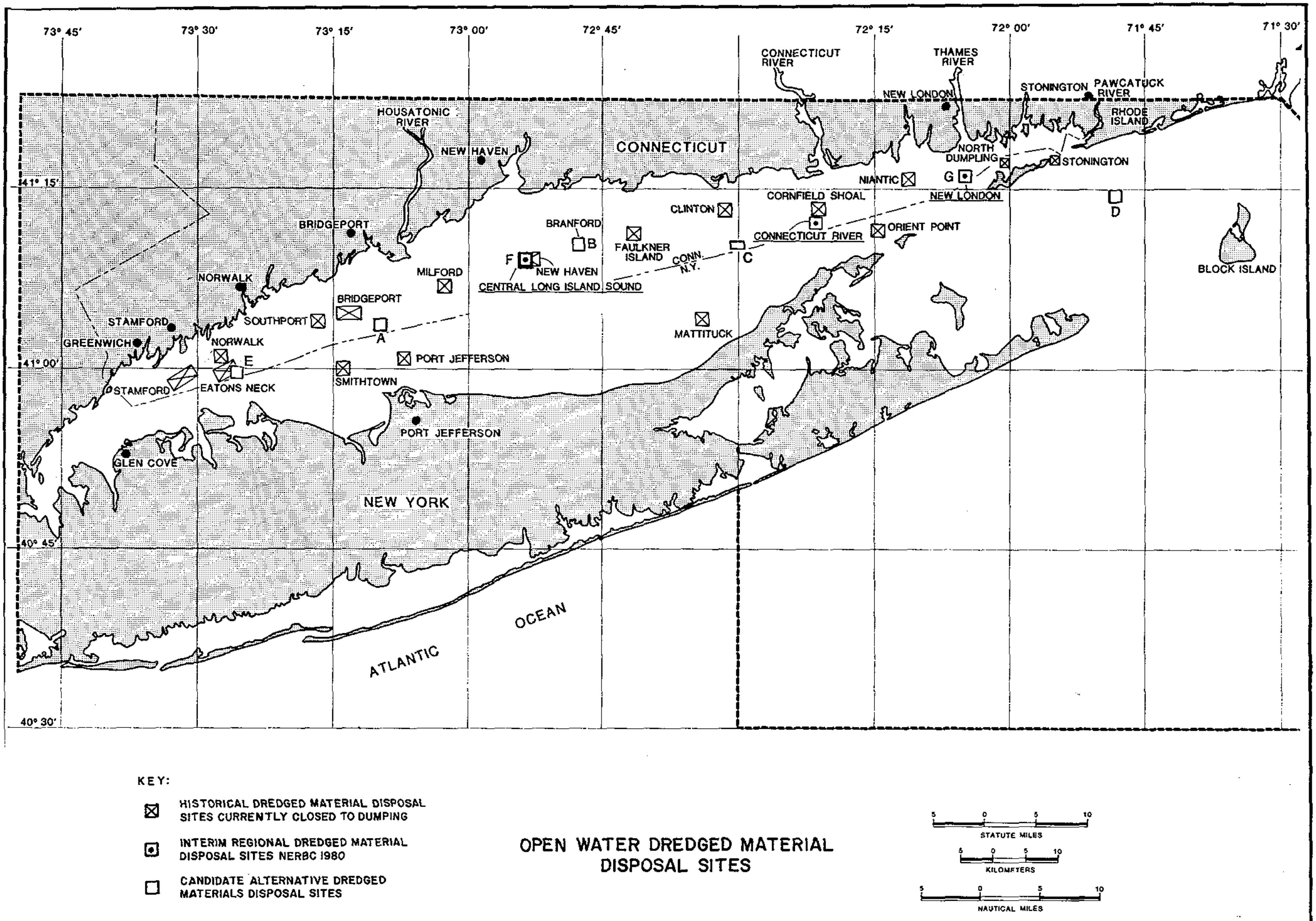
Before 1974, there were 19 dredged material disposal sites in Long Island Sound (Figure I.A-2). In the mid 1970's, the National Resources Defense Council (NRDC) brought suit against the Corps of Engineers regarding the disposal of dredged materials (from the Navy's Thames River Project) in the New London disposal site off the mouth of the Thames River (NRDC vs. Callaway, No. H-74-268). One of the major issues raised in that litigation was the need for a comprehensive evaluation of alternatives for open water disposal. The New England Division, Corps of Engineers is preparing an EIS to address, on a regional basis, the impacts related to open water disposal of dredged material. This is partly in response to an agreement reached among parties involved in the referenced suit.



STUDY AREA FOR OPEN WATER DISPOSAL

NOTE: ISOBATHS IN METERS

FIGURE I.A-1



OPEN WATER DREDGED MATERIAL DISPOSAL SITES

FIGURE 1,A-2

In 1976, recognizing the need to resolve disposal issues, the Connecticut Department of Environmental Protection and the New York Department of Environmental Conservation drafted an interim plan for management of open water disposal. The draft was revised in 1979 and has been circulated for review by the New England River Basins Commission (NERBC, 1979).

The draft interim plan outlines general types of materials to be considered suitable for disposal in the Sound and identified four locations as regional disposal sites. Three areas are to be kept available for interim dredged material disposal: the Central Long Island Sound Regional Dredged Material Disposal Area, in the vicinity of the historical New Haven dumping grounds; the Connecticut River Regional Dredged Material Disposal Area, in the vicinity of the historical Cornfield Shoals dumping grounds; and the historical New London dumping grounds.

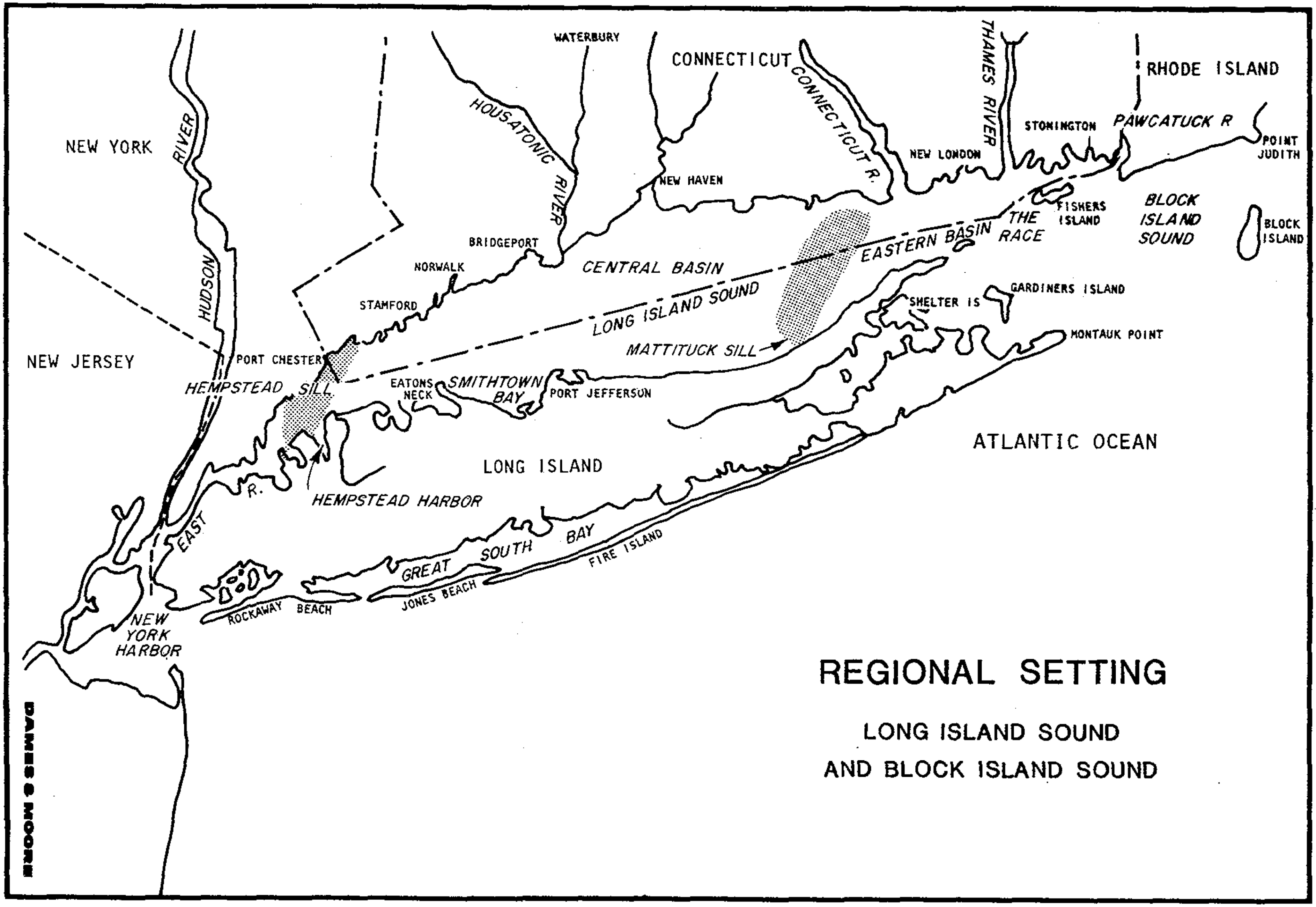
Regulations for preparing environmental impact statements, published on November 29, 1978, by the President's Council on Environmental Quality (CEQ), call for the use of a scoping process. Scoping meetings, as outlined in the CEQ regulations, are intended to "...assist agencies in deciding what the central issues are, how long the EIS shall be, and how the responsibility for the EIS will be allocated among the lead agency and the cooperating agencies." The Corps of Engineers conducted public scoping meetings at three locations during the first week of May, 1979 at Warwick, Rhode Island; New Haven, Connecticut; and Huntington Station, New York to obtain the views of the interested citizens and organizations regarding the significant issues to be addressed in consideration of the site selection for, and the impacts of, open water disposal. In addition, Dames & Moore conducted a series of interviews with various State, Federal, and local representatives and interest groups to further identify key issues and concerns. A summary of key issues raised during the interviews and the interview list is presented in Appendix B. Appendix C presents the synthesis of issues raised at the scoping meetings, prepared by the New England Division, Army Corps of Engineers.)

I.B Regional Setting

The elongate body of water lying between the southern New England coastline of Connecticut and Rhode Island, and Long Island, New York, is termed the Long Island Sound. This body of water has free connection with the North Atlantic Ocean on its eastern margin, where it merges with Block Island Sound. Its western connection to the sea is more restricted, passing through a series of narrows, and thence down the East River to join New York Harbor and the New York Bight (Figure I.B-1).

Block Island Sound is an extension of the southern New England inner continental shelf. It has free communication with shelf waters, and is, in comparison to Long Island Sound, more exposed to the open ocean environment than Long Island Sound.

Both Long Island and Block Island Sounds lie adjacent to high-density population centers and heavy industry. Such intensive land use has resulted in a variety of impacts on the waters and sediments of the Sounds. They receive sewage effluents; waste heat; runoff from urban, surburban, and agricultural areas; dredged materials; and spilled or flushed materials from commercial and recreational vessels. At the same time, these waters support both finfish and shellfish industries; recreational fisheries and boating; bathing; and aesthetic pursuits of both residents and visitors. Such intensive use places physical stress on the ability of the waters to



REGIONAL SETTING

LONG ISLAND SOUND AND BLOCK ISLAND SOUND

DAMES & MOORE

FIGURE I.B-1

assimilate man's by-products and ecological stresses on the plants and animals inhabiting the waters and sediments. A thorough treatment of the various uses will be found in Koppelman and others (1976); the Interim Plan for Disposal of Dredged Material in Long Island Sound (New England River Basin Commission ((NERBC)), 1979); the series "People and the Sound" (NERBC, various dates); and the Reconnaissance Report Dredged Material Containment in Long Island Sound (U.S. Army Corp Engineers ((U.S. ACOE)), 1979).

I.C Laws and Regulations Affecting Dredged Material Disposal

There is an extensive literature describing regulations concerning open water disposal of dredged materials. The following summary, adapted from the report prepared for the New York District (Conner et al., 1979) , provides a condensed description of the pertinent legislation, regulations and guidelines now in effect.

Numerous Federal statutes apply, either directly or indirectly, to open water disposal of dredged materials. Of primary concern are:

- Section 404 of the Federal Water Pollution Control Act of 1972, as amended, (PL 92-500, 33 U.S.C. 1344), and
- Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (PL 92-532, 33 U.S.C. 1413).

Related legislation includes the Coastal Zone Management Act of 1972, as amended (16 U.S.C. 1451 et seq.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. 661 et seq.), the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.), and the Safe Drinking Water Act of 1972 (42 U.S.C. 1401 et seq.).

I.C.1 Section 404 of the Federal Water Pollution Control Act Amendment of 1972

The discharge of pollutants from point sources into the waters of the United States is prohibited by Section 301 of the Federal Water Pollution Control Act of 1972 (FWPCA) unless the discharge is in compliance with Sections 402 and 404 of the Act. Section 402 establishes the National Pollutant Discharge Elimination System (NPDES) which is administered by the Administrator of the Environmental Protection Agency (EPA). Section 404 of the FWPCA establishes a permit program, administered by the Secretary of the Army, acting through the Chief of Engineers, to regulate the discharge of dredged or fill material into the waters of the United States. Navigable waters of the United States, as defined in 33 CFR 329, are the traditional waters where permits are required under Sections 9 and 10 of the River and Harbor Act of 1899. Waters of the United States, on the other hand, are defined in 33 CFR 323.2(a). Long Island Sound and portions of Block Island Sound are subject to Section 404.

Applications for Section 404 permits are evaluated using guidelines developed by the Administrator of EPA, in conjunction with the Secretary of the Army (40 CFR 230). The Chief of Engineers can make a decision to issue a permit that is inconsistent with those guidelines if the interests of navigation require it. Section 404(c) gives the EPA Administrator further authority, subject to certain procedures, to restrict or prohibit the discharge of any dredged or fill material that may cause an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas.

Further modifications and clarifications to the September 5, 1975, Interim Final Guidelines (40 CFR 230) regarding the discharge of dredged or fill material into U.S. waters appeared in the Federal Register of September 18, 1979. They reflect the 1977 Amendments of Section 404 of the FWPCA and clarify definitions and explanations of adverse impacts. Although the EPA has published these Guidelines as proposed regulations, experience indicates that the various policies described in this publication will be adopted. We have thus drawn extensively upon the subparts contained in the Guidelines, as they relate specifically to open water disposal in both Long Island and Block Island Sounds.

In addition to these requirements, State water quality certification compliance is required by Section 401 of the FWPCA.

I.C.2 Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972

The Marine Protection, Research and Sanctuaries Act of 1972 (commonly referred to as the Ocean Dumping Act) contains provisions that resemble the permitting approach taken by the FWPCA. Specifically, Section 103 of the Act is similar to Section 404 of the FWPCA in that it creates a separate permit program to be administered by the Secretary of the Army, acting through the Chief of Engineers, to authorize the transportation of dredged material in ocean water for disposal at designated disposal sites. The Act requires the Corps of Engineers to make the same evaluation for dredged material that is required of the EPA Administrator for the ocean disposal of other materials, using the ocean disposal criteria developed by the Administrator. The Act also requires the Corps of Engineers to utilize, to the maximum extent feasible, ocean disposal sites that have been designated by the EPA Administrator.

If the EPA criteria prohibit ocean disposal, the Act requires the Corps of Engineers to make an independent determination as to the need for the proposed disposal based upon an evaluation of the potential effect that would occur to navigation, economic and industrial development, and foreign and domestic commerce of the United States if a permit were denied. An independent determination as to other proposed methods of disposal of dredged material and appropriate locations for ocean disposal must also be made by the Corps of Engineers in the review of applications for ocean disposal.

No permit may be issued to dispose of dredged material in the oceans if the disposal does not comply with the EPA criteria unless the Secretary of the Army seeks a waiver of the criteria from the Administrator after certifying that there is no other economically feasible method or site available than the proposed disposal site under consideration. The Act requires the Administrator to grant this waiver unless he finds that the proposed disposal will result in an unacceptable adverse impact on municipal water supplies, shellfish beds, wildlife, fisheries, or recreational areas.

The legal requirements of the Ocean Dumping Act apply to ocean waters which are defined as those waters of the open seas lying seaward of the baseline from which the territorial sea is measured (42 FR 2469). Therefore the site selection criteria for ocean dumping developed by the EPA under Section 103 apply strictly only in portions of Block Island Sound and the adjacent open ocean waters. Long Island Sound waters are not included under the provisions of the Ocean Dumping Act. The EPA site selection criteria do, however, represent a comprehensive list of concerns which should be addressed in identifying disposal sites in any open water location. These criteria were therefore used as the basis for site selection throughout the study area as described in Section II of this report.

I.C.3 Other Federal Legislation

Section 307(c) of the Coastal Zone Management Act of 1972 requires that Federal agencies (whose activities may directly affect a state's coastal zone) comply to the maximum extent practicable, with an approved state coastal zone management program. It also requires that certification of compliance with the management program be provided by any non-Federal applicant for a Federal license or permit to conduct an activity affecting land or water uses in the state's coastal zone.

The Fish and Wildlife Coordination Act expresses the concern of Congress with the quality of the aquatic environment as it affects the conservation, improvement, and enjoyment of fish and wildlife resources. There is outstanding a Memorandum of Understanding between the Secretary of the Interior and the Secretary of the Army, dated 13 July 1967, providing procedures for coordinating the concerns of both agencies (see Appendix B of the Corps of Engineers Final Regulations dated 19 July 1979).

The National Environmental Policy Act of 1969 declares the national policy to encourage a productive and enjoyable harmony between man and his environment. Section 102 of the Act directs that "to the fullest extent possible: (1) The policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this Act, and (2) all agencies of the Federal Government shall ... insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical considerations ..." Detailed environmental impact statements are required if a proposed major Federal action would significantly affect the quality of the human environment.

Other Federal laws that may bear on dredged material disposal include:

- The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.), which states inter alia that Federal agencies ensure that their actions do not jeopardize the continued existence of endangered or threatened species or result in the destruction of critical habitat;

- The National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.), which requires that agencies consider potential impacts on significant historical or archaeological resources; and

- Section 302 of the Ocean Dumping Act, which authorizes the Secretary of Commerce to issue regulations to control activities within areas of the ocean waters or Great Lakes which have been designated as marine sanctuaries.

I.D Sources and Nature of Dredged Materials

I.D.1 Sources

There are numerous existing federal and non-federal projects in Connecticut, Rhode Island and New York which require periodic maintenance dredging to maintain the navigability of channels, ports, harbors and marinas. In addition, new dredging work will be required to further enhance the commercial and recreational viability of these existing facilities as well as to develop additional new facilities. Due to the recent environmental controversy over open water disposal of dredged material and the lack of available long-term open water disposal sites there are several currently pending dredging projects which would have normally been scheduled for maintenance work during the past few years.

The federal projects in the vicinity of the Long Island Sound and Block Island Sound authorized by Congress under various River and Harbor Acts, are identified in Tables I.D-1 and I.D-2. The locations of authorized federal projects in the vicinity of the study area are depicted on Figure I.D-1. Dredged material volume projections for Connecticut were developed by the Army Corps of Engineers, New England Division (January, 1979). Projected dredged material volumes for Rhode Island and New York developed for this study are based on available historical dredging statistics (Seavey and Pratt, 1979; U.S. Army Corps of Engineers, New York District, May 1979).

During the ten-year period 1968-1978, about 6.5 million cubic yards of material dredged from Connecticut waters were disposed of at open water sites in the Long Island Sound. Over the same ten-year period, Long Island Sound disposal from New York State sources totalled about 1.4 million cubic yards (NERBC, 1979).

Based on New England Division Corps of Engineers dredged material volume projections for the period 1980-2035, it is anticipated that federal dredging projects in Connecticut and Rhode Island in the vicinity of the Long Island Sound and Block Island Sound, will produce about 42.8 million cubic yards of dredged material. It is estimated that more than 70 percent of this volume will be due to maintenance dredged material projects, and 64 percent will originate in the central coastal area of the Long Island Sound (Table I.D-3). The total projected Connecticut and Rhode Island dredging volumes for all federal and non-federal projects in the study area for the period 1980-2035 are estimated to be about 65 million cubic yards (Refer to Table I.D-4 for breakdown of federal and non-federal totals by area). Federal dredging projects account for 66 percent of this total. Overall, 60 percent of the total material will originate in the Central Long Island Sound coastal area of Connecticut.

An estimated 39 million cubic yards of dredged material for the State of New York federal projects in the vicinity of Long Island Sound and Block Island Sound are anticipated during the same 55 year period (Table I.D-5). About 92 percent of that volume will originate in the area adjacent to the extreme western end of the Long Island Sound. In the absence of projected dredging data for New York State, it has been assumed that the total federal new-work will involve approximately half the volume of the New York maintenance dredging volume projections. This assumption is consistent with available historical dredging statistics for all federal projects within the New York District, Corps of Engineers for the 11 year period 1966 to 1976 (May, 1979). Similarly, based on available historical data for dredging projects during the period 1970 - 1976 listed in Table I.D-2, it has been assumed that over the period 1980-2035, all non-federal dredging will be equal to 30% of all federal project dredging (U.S. Army Corps of Engineers, New York District, 1979). Based on these assumptions, it is estimated that approximately 51 million cubic yards of dredged material will be produced by New York State projects in the vicinity of the study area. (See Table I.D.-6)

TABLE LD-1

AUTHORIZED FEDERAL DREDGING PROJECTS
CONNECTICUT AND RHODE ISLAND COASTAL AREAS – LONG ISLAND SOUND
NEW ENGLAND DIVISION ARMY CORPS OF ENGINEERS
(Volume in Thousands of Cubic Yards)

LONG ISLAND SOUND COASTAL AREAS/ PROJECT LOCATION[1]		Dredging Tentatively Under Consideration		Projected Maintenance Dredging 1985-2035		
Map Key No.	Project Name	Planned Maintenance 1980-1985	Planned New Dredging 1980-2035	Average Annual Maintenance Volume	50-year Cumulative Maintenance Volume	Total Planned and Projected Dredging 1980-2035
	WESTERN INCLUDING HOUSATONIC RIVER					
1	Port Chester Harbor	NA	—	NA	NA	—
2	Greenwich Harbor	50	—	4.0	200	250
3	Mianus	35	—	2.8	140	175
4	Stamford Harbor	150	—	12.0	600	750
5	Westcott Cover	20	—	2.8	140	160
6	Fivemile River Harbor	70	—	5.6	280	350
7	Wilson Point Harbor	NA	—	NA	NA	—
8	Norwalk Harbor	—	—	28.0	1400	1400
9	Westport Harbor and Saugatuck River	80	—	9.5	480	560
10	Southport Harbor	50	—	4.0	200	250
11	Block Rock Harbor[2]	—	150	—	—	150
12	Bridgeport Harbor	350	2500	18.0	900	3750
13	Housatonic River	200	—	28.0	1400	1600
	Subtotal	1005	2650	114.8	5740	9395
	CENTRAL INCLUDING CONNECTICUT RIVER					
14	Milford Harbor	100	—	8.0	400	500
15	New Haven Harbor	—	7200	150.0	7500	14700
16	Branford Harbor	100	—	14.0	700	800
17	Stoney Creek	35	—	4.9	245	280
18	Guilford Harbor	70	—	9.8	490	560
19	Clinton Harbor	—	230	4.2	210	440
20	Duck Island Harbor	—	—	4.0	200	200
21	Patchague River	100	30	7.0	350	480
22	Connecticut River Projects:					
	Eightmile	NA	NA	NA	NA	—
	North Cover	NA	NA	NA	NA	—
	Essex Cover	NA	NA	NA	NA	—
	Wethersfield Cove	NA	NA	NA	NA	—
	River Channel	NA	NA	NA	NA	—
	Connecticut River Below Hartford	950	—	150.0	7500	8450
	Subtotal	1355	7460	351.9	17,595	26,410
	EASTERN AREA INCLUDING THAMES RIVER AND BLOCK ISLAND SOUND					
23	Niantic Bay/Harbor	40	—	5.6	280	320
24	Thames River	200	—	16.0	800	1000
25	New London Harbor	—	1600	50.0	2500	4100
26	Mystic River	—	—	2.0	100	100
27	Stonington Harbor	NA	NA	NA	NA	—
28	Pawcatuck River, CT & RI	100	—	7.0	350	450
	Subtotal	340	1600	80.6	4030	5970
	Connecticut Totals	2700	11,710	—	27,365	41,773
29	Little Narragansett Bay and Watch Hill Cove	20	—	NA	—	20
30	Point Judith Harbor of Refuge and Channel	30	—	10.0	500	530
31	Block Island Harbor of Refuge	25	—	4.0	200	225
32	Block Island Great Salt Pond	50	—	4.0	200	250
33	Hay (West Harbor, Fishers Island)	—	—	NA	NA	—
	Rhode Island Totals	125	0[3]	—	900	1,025
	GRAND TOTAL	2,825	11,710	—	28,265	42,300

NOTES:

(1) Refer to Figure ID-1 for Project Locations.

(2) Block Rock Harbor is under consideration but not yet authorized. The average annual projected maintenance volume for the Block Rock Harbor is included under the Bridgeport Harbor Project.

(3) Over the last 15 years, new dredging in Rhode Island has been extremely rare. (U.S. Army Corps of Engineers, New England Division, January, 1979).

Sources:

Planned and Projected Dredging Volumes for Connecticut Projects were adapted from U.S. Army Corps of Engineers, New England Division, January 1978.

Planned Rhode Island Projects were taken from Seavey and Pratt, February 1979. Projected Maintenance Dredging for the Rhode Island projects was estimated by Dames & Moore from historical data included in Seavey and Pratt, 1978.

TABLE I.D-2

AUTHORIZED FEDERAL DREDGING PROJECTS
PROJECTED MAINTENANCE DREDGING
NEW YORK DISTRICT ARMY CORPS OF ENGINEERS[1]
(Volume in thousands of cubic yards)

	Project Location		Projected Maintenance (1980-2035)	
Coastal Area	Map Key Number[2]	Project Name	Avg. Annual Maintenance Volume	Cumulative Maintenance Volume
Eastern	34	Lake Montauk Harbor	15	825
Long Island Sound &	35	Sag Harbor	6	330
Block Island Sound	36	Peconic River	6	330
	37	Greenport Harbor	4	220
Subtotal			31	1705
Central	38	Mattituck Harbor	8	440
Long Island Sound	39	Port Jefferson Harbor	NA	NA
Subtotal			8	440
Western	40	Northport Harbor	6	330
Long Island Sound	41	Huntington Harbor	8	440
	42[3]	Glen Cove Harbor	NA	NA
	43[3]	Glen Cover Creek	8	440
	44[3]	Hempstead Harbor	1	55
	45[4]	Little Neck Bay	NA	NA
	46[3],[4]	Flushing Bay and Creek	100	5,500
	47[3],[4]	East River	96	5,280
	48[3],[4]	Newtown Creek	49	2,695
	49[3],[4]	Harlem River	28	1,540
	50[3],[4]	Bronx River	22	1,210
	51[3],[4]	Westchester Creek	36	1,980
	52[3]	East Chester Creek	20	1,100
	53[3]	New Rochelle Harbor	2	110
	54[3]	Echo Bay Harbor	0.4	22
	55[3]	Larchmont Harbor	NA	NA
	56[3]	Mamaroneck Harbor	19	1,045
	57[3]	Milton Harbor Rye, N.Y.	30	1,650
	58[3]	Port Chester Harbor	10	550
Subtotal			435.6	23,942
GRAND TOTAL				26,092

Notes:

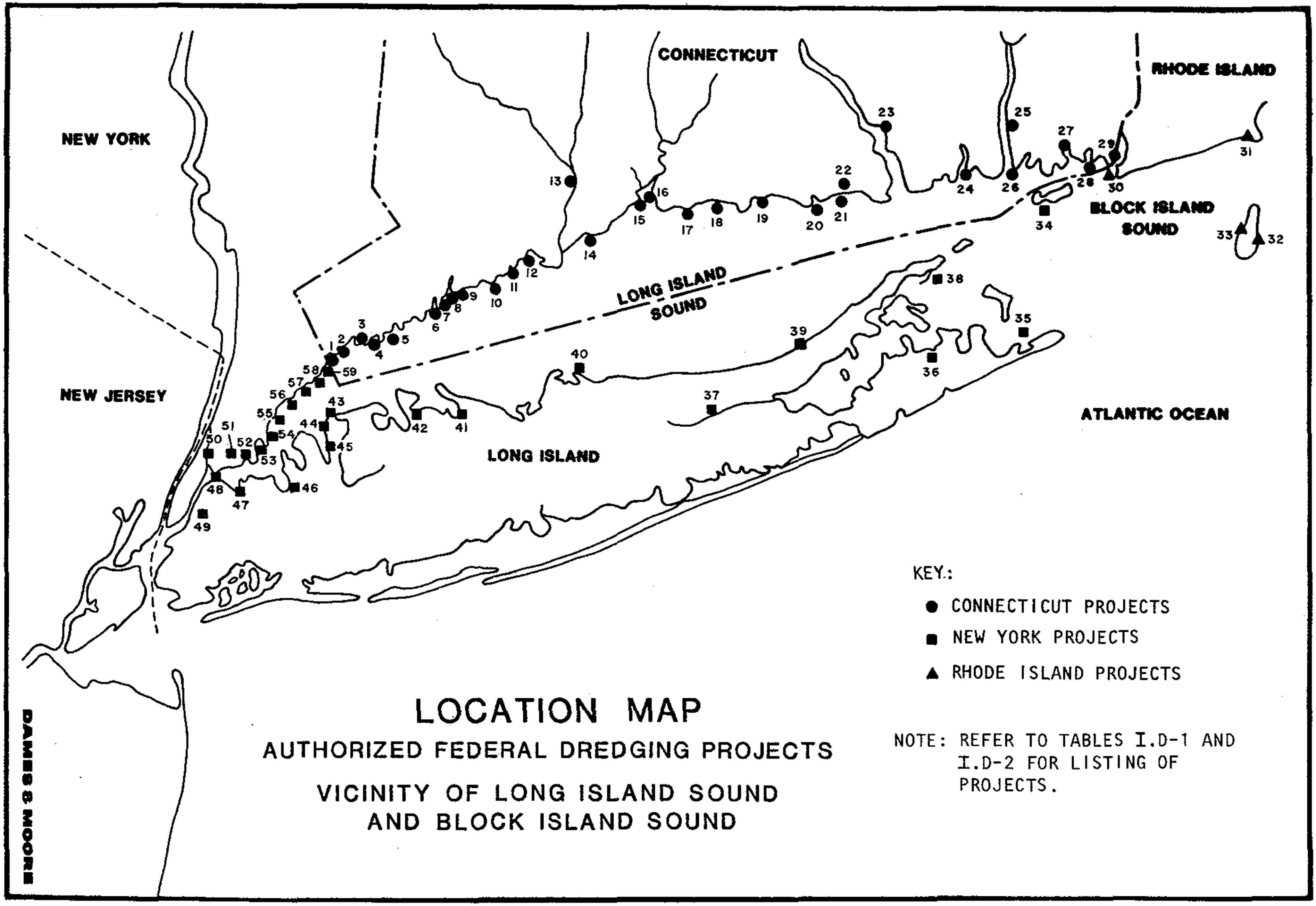
[1]This table includes authorized New York District projects which are located in the immediate vicinity of the Long Island Sound or have used the Long Island Sound for dredged material disposal during the period 1965-1979.

[2]Refer to Figure I.D-1 for the location of projects.

[3]Designated projects are documented to have used the Long Island Sound sites for some disposal since 1965.

[4]Most recently these projects have used the Mud Dump Dredged Material Disposal Site in the New York Bight.

Source: Projected Maintenance Volumes estimated from available historical dredging data from U.S. Army Corps of Engineers, New York District, May, 1979.



LOCATION MAP

AUTHORIZED FEDERAL DREDGING PROJECTS

VICINITY OF LONG ISLAND SOUND AND BLOCK ISLAND SOUND

NOTE: REFER TO TABLES I.D-1 AND I.D-2 FOR LISTING OF PROJECTS.

FIGURE I.D-1

TABLE I.D-3

PLANNED AND PROJECTED FEDERAL DREDGING IN THE VICINITY OF
LONG ISLAND SOUND AND BLOCK ISLAND SOUND
CONNECTICUT AND RHODE ISLAND
NEW ENGLAND DIVISION ARMY CORPS OF ENGINEERS
(1980 - 2035)
(Volume in thousands of cubic yards)

Coastal Area	New Work	Maintenance	Totals*	Percent
Western Long Island Sound	2,650	6,745	9,395	23
Central Long Island Sound	7,460	18,950	26,410	64
Eastern Long Island Sound and Block Island Sound	1,600	5,395	6,995	14
TOTALS	11,710	31,090	42,800	100%
	27%	73%	100%	

*Refer to Table I.D-1 for a further breakdown of federal projects.

Source: Adapted from U.S. Army Corps of Engineers, New England Division, January 1979.

TABLE I.D-4

TOTAL DREDGED MATERIAL VOLUME PROJECTIONS
PROJECTS IN THE VICINITY OF
LONG ISLAND SOUND AND BLOCK ISLAND SOUND
CONNECTICUT AND RHODE ISLAND
NEW ENGLAND DIVISION ARMY CORPS OF ENGINEERS
(1980 - 2035)
(Volume in millions of cubic yards)

Coastal Area	All* Federal Dredging	All Non-Federal Dredging	Totals	Percent
Western Long Island Sound	9.395	3.63	13.025	20
Central Long Island Sound	26.410	12.43	38.84	60
Eastern Long Island Sound and Block Island Sound	6.995	6.05	13.05	20
TOTALS	42.80	22.11	64.91	100%
	66%	34%	100%	

*Refer to Table I.D-3 for a further breakdown of federal projects.

Source:
Adapted from U.S. Army Corps of Engineers, New England Division, January 1979.

TABLE I.D-5

PROJECTED FEDERAL DREDGING IN THE VICINITY OF LONG ISLAND SOUND[1]

NEW YORK DISTRICT ARMY CORPS OF ENGINEERS

(1980 - 2035)

(Volume in thousands of cubic yards)

Coastal Area	Maintenance	New Work[2]	Totals	Percent
Western Long Island Sound	23,947	11,975	35,922	92
Central Long Island Sound	440	220	660	2
Eastern Long Island Sound and Block Island Sound	1,705	850	2,555	6
TOTALS	26,092	13,045	39,137	100%
	67%	33%	100%	

[1]Refer to Table I.D-2 for a further breakdown of federal projects.

[2]For this projection of dredged material volumes it has been assumed that the ratio of maintenance to new work dredging is 2 to 1 for Federal Projects in New York State. This ratio is consistent with historical New York District Corps dredging statistics for the period 1966-1971 (U.S. Army Corp of Engineers, New York District, May 1979).

TABLE I.D-6

TOTAL DREDGED MATERIAL VOLUME PROJECTIONS
PROJECTS IN THE VICINITY OF
LONG ISLAND SOUND AND BLOCK ISLAND SOUND
NEW YORK DISTRICT ARMY CORPS OF ENGINEERS
(1980 - 2035)
(Volume in thousands of cubic yards)

Coastal Area	All Federal Dredging[1]	All Non-Federal Dredging[2]	Totals	Percent
Western Long Island Sound	35,922	10,777	46,699	92
Central Long Island Sound	660	198	858	2
Eastern Long Island Sound and Block Island Sound	2,555	767	3,322	6
TOTALS	39,137	11,742	50,879	100%
	77%	23%	100%	

[1]Refer to Table I.D-5 for a further breakdown of federal projects.

[2]Based on Historical Disposal volumes for the projects in the New York District for the period 1970-1976 (U.S. Army Corps of Engineers, N.Y. District, 1979) the total non-federal dredging volumes were assumed to be equal to 30% of the total Federal dredging volumes

The projected total volumes for all dredging under the jurisdiction of the New England Division and New York District Corps of Engineers by area, and the corresponding average annual dredged volumes derived from the 1980 to 2035 projections, are presented in Table I.D-7. The overall total projected volume of dredged material that will be produced in the 55 year study period is estimated to be about 116 million cubic yards. Normally, however, not all dredged material is disposed of at open water sites. During the last 10 to 15 years, between 50 and 70 percent of materials dredged from all federal and non-federal projects in the vicinity of Long Island Sound and Block Island Sound have gone to open water sites (NERBC, 1979; New England Division, 1979; New York District, 1979). The estimated total annual open water dredged material disposal volume for the study area are presented in Table I.D-8. These estimates have been generated by assuming that 60 percent of the total average annual dredged material volumes produced in the study area will be dumped at open water sites.

Since 1972, a majority of the New York State projects listed in Table I.D-2 have utilized the Mud Dump Disposal Site in the New York Bight. This is primarily a result of the closing of the open water sites in the western Long Island Sound. Some of the New York State projects used the historical Eatons Neck and Stamford Dredged Material Disposal Sites in Long Island Sound prior to 1972 (Table I.D-2).

If it is assumed that 60 percent of all open water disposal of dredged materials would be disposed of in Long Island and Block Island Sounds, a total volume of approximately 1.3 million cubic yards of material disposal would require disposal annually. About 52 percent of this volume would be generated in the western Long Island Sound area, 34 percent in the central Long Island Sound area and 14 percent in the eastern Long Island Sound to Block Island Sound area. If it is assumed that material from New York District projects would continue to be disposed of elsewhere and that only Connecticut and Rhode Island projects in the vicinity of the study area would utilize those bodies of water for disposal, then approximately 0.7 to 0.8 million cubic yards of open water disposal of dredged material each year is anticipated. Approximately 60 percent of this annual volume would be generated in the central Long Island Sound area, with the remaining quantities being divided equally between the western Long Island areas and the eastern Long Island Sound and Block Island Sound. The estimated total annual volume of open water dredged material disposal by areas is summarized in Table I.D-8.

It is significant to note that the dredging and disposal estimates presented herein have been based on planned dredging and an orderly schedule of maintenance and new dredging, estimated from available historical dredging statistics and projected over the 55-year period 1980-2035. Any variations in planned or projected dredging any unscheduled dredging, or changes in availability of upland and open water disposal sites could cause a significant change in the long-term and average annual dredge material volumes. In turn, the demands on particular open water disposal sites in the study area could also vary considerably with time.

I.D.2 Character of Dredged Material

Typically, dredged materials from maintenance projects are finer-grained and potentially more contaminated with organics, oil and grease, and trace metals than the dredged materials produced during improvement or new-work projects. The character of the maintenance dredged material is, however, expected to improve with respect to contaminant concentrations as a result of the control of pollutant discharges by the EPA under the NPDES program.

TABLE I.D-7

TOTAL DREDGED MATERIAL VOLUME PROJECTIONS
AND AVERAGE ANNUAL DREDGE VOLUMES*
PROJECTS IN THE VICINITY OF LONG ISLAND SOUND AND BLOCK ISLAND SOUND
(1980 - 2035)
(Volume in millions of cubic yards)

Coastal Area	Projected Total All Dredging N.E. Division C.O.E.	Projected Total All Dredging N.Y. District C.O.E.	Total
Western Long Island Sound	13.03 0.237 per yr.	46.70 0.85 per yr.	59.73 1.09 per yr.
Central Long Island Sound	38.84 0.706 per yr.	0.86 0.02 per yr.	39.70 0.72 per yr.
Eastern Long Island Sound and Block Island Sound	13.05 0.237 per yr.	3.32 0.06 per yr.	16.37 0.30 per yr.
TOTAL	64.92 1.18 per yr.	50.88 0.93 per yr.	115.80 2.11 per yr.

*Historically, approximately 60% of the total volume of dredged material from the New England and New York District projects in the vicinity of the Long Island Sound and Block Island Sound have been disposed at open water sites. Refer to Table I.D-8 for estimates of total annual open water disposal volumes.

TABLE I.D-8

ESTIMATED ANNUAL OPEN WATER DREDGED MATERIAL DISPOSAL[1]
PROJECTS IN THE VICINITY OF
LONG ISLAND SOUND AND BLOCK ISLAND SOUND
(Volume in thousands of cubic yards)

Coastal Area	Projected Annual Estimate N.E. Division		Projected Annual Estimate[2] N.Y. District		Totals	
Western Long Island Sound	142	20%	509	92%	651	52%
Central Long Island Sound	424	60%	9	1%	433	34%
Eastern Long Island Sound and Block Island Sound	142	20%	36	7%	178	14%
TOTAL	708		554		1,262	
Percent	56%		44%		100%	

[1]Annual open water disposal volumes assumed to be 60% of total average volumes dredged annually in each area.

[2]Since 1972 a majority of the New York District projects requiring open water disposal have used the Mud Dump Disposal Site in the New York Bight (U.S. Army Corps of Engineers, May 1979).

The relationships between projected maintenance and new-work dredging for New England Division and New York District (federal projects) in the study area are provided in Tables I.D-3 and I.D-5, respectively. The relationships between non-federal new and maintenance work are, however, not readily available. In general it may be assumed that approximately 60 percent or more of all dredging volume over the next 50 years will be generated from maintenance projects. The actual "quality" of the maintenance material sediments will be a function of grain size, the proximity of the source location to industrial centers, and the actual levels of pollutants or pollution constituents in the material.

A summary of dredged material characteristics for selected New England Division, Corps of Engineers projects (primarily Connecticut waterways and harbors) is presented in Table I.D-9. The summary includes a composite range and average for various textural, engineering character, and bulk chemical parameters for materials from the selected projects. Materials from the selected projects include representative samples from varying depths below bottom and of different grain size. This general characterization reflects the influence of contaminant inputs, predominantly to the Connecticut harbor areas adjacent to industrialized and urban areas.

TABLE I.D-9

SUMMARY OF DREDGED MATERIAL CHARACTERISTICS FOR SELECTED PROJECTS*
NEW ENGLAND DIVISION, ARMY CORPS OF ENGINEERS

Parameters	Number of Observation	Range of Values: Lowest	Range of Values: Highest	Mean (Avg. Value)	Standard Deviation
Median grain size (mm)	392	0.001	14.000	0.234	1.005
Sorting coefficient	386	0.5	44.7	3.25	2.98
Percent fines (clay and silt)	394	0.0	100.0	67.1	NA
Liquid limit	301	25	221	86	37
Plastic limit	301	17	83	42	13
Plastic index	301	2	172	45	26
Specific gravity solids	401	2.19	2.79	2.609	0.097
Wet unit weight (pcf)	267	46.70	138.50	95.16	16.66
Dry unit weight (pcf)	268	8.70	118.70	51.78	25.03
Percent solids	569	7.85	88.60	51.19	18.43
pH	367	5.6	9.6	7.4	0.44
Sediment redox potential (MV)	162	-0.35	399.50	16.26	51.79
% volatile solids	370	0.12	20.49	5.38	4.19
% total volatile solids	357	1.42	43.00	10.99	7.95
Chemical oxygen demand (ppm)	363	980	425,000	98,012	80,739
Total Kjdl. nitrogen (ppm)	364	0.0	11,860	2,630	2,103
Oil and grease (ppm)	364	0.0	73,500	4,840	8,501
Mercury (ppm)	602	0.00	11.00	0.795	1.211
Lead (ppm)	601	5.00	5,100.00	145.19	282.86
Zinc (ppm)	601	11.00	2,986.00	282.75	363.36
Arsenic (ppm)	598	0.00	63.50	7.20	8.76
Cadmium (ppm)	601	0.10	141.00	5.76	10.58
Chromium (ppm)	598	2.00	3,528.00	159.96	311.54
Copper (ppm)	601	2.00	9,300.00	259.57	533.98
Nickel (ppm)	600	5.00	415.00	49.34	44.71
Vanadium (ppm)	599	5.00	730.00	62.35	47.53
% Carbon (total)	149	0.12	13.23	3.750	2.215
% Hydrogen	149	0.01	3.59	0.860	0.557
% Nitrogen	149	0.00	2.98	0.407	0.352
DDT (ppb)	44	0.007	1,160	115.7	234.6
Plychl biph (ppb)	44	0.007	3,000	428.7	675.7

*Selected projects primarily from Connecticut Waterways and Harbors.
Source: New England Division Corps of Engineers, open file data January, 1979.

II. THE ALTERNATIVE SITES

Seven specific areas have been identified as candidate sites for offshore disposal of dredged materials. They are:

A. Bridgeport East, CT; includes portion of old Bridgeport site, western Long Island Sound.
B. Branford, CT; central Long Island Sound, includes old Branford Site.
C. Six Mile Reef offshore of Clinton, CT; east central Long Island Sound.
D. Block Island Sound offshore of Pawcatuck River, CT and RI; western Block Island Sound.
E. Eatons Neck East, CT; western Long Island Sound.
F. New Haven, CT; central Long Island Sound.
G. New London, CT; eastern Long Island Sound.

These sites were identified through a comprehensive site selection and evaluation study which included the following major components:

- An extensive review of published data covering the study area,
- A computerized geographic-based evaluation of environmental considerations relating to dredged material disposal, and
- A selection of candidate recommended sites for further study at a site specific level of evaluation.

II. A. DATA COMPILATION

The first step in the site selection process was an extensive literature search to obtain data on the study area with respect to its chemical, physical, biological, resource, and use characteristics (see References). These data were then evaluated for overall data reliability, geographic detail, and locational accuracy. The data were then mapped at a scale of 1:250,000 in preparation for conversion to a computer compatible format for use in subsequent phases of the study.

Appendix A provides a detailed discussion of the site selection analysis. With respect to data compilation, it discusses the development of specific source data maps, the references from which the data are derived, and the general quality and coverage of the data.

II. B. ENVIRONMENTAL SUITABILITY ANALYSIS

The purpose of this analysis is to screen all portions of the study area to identify those portions which are the most environmentally suitable for the open water disposal of dredged material. Assumptions on which this analysis is based are:

1. The dredged material to be disposed of would be fine-grained and contain many potential contaminants; and
2. That confinement of the deposited dredged materials of the type discussed would be the most appropriate and environmentally conservative approach.

II.B.1 Suitability Criteria

The analysis was structured to give due consideration to Federal Guidelines for selection of open water disposal sites. The specific siting criteria as outlined in the EPA Ocean Dumping Regulations, Sections 228.5 and 228.6 (42 Federal Register 2483) are:

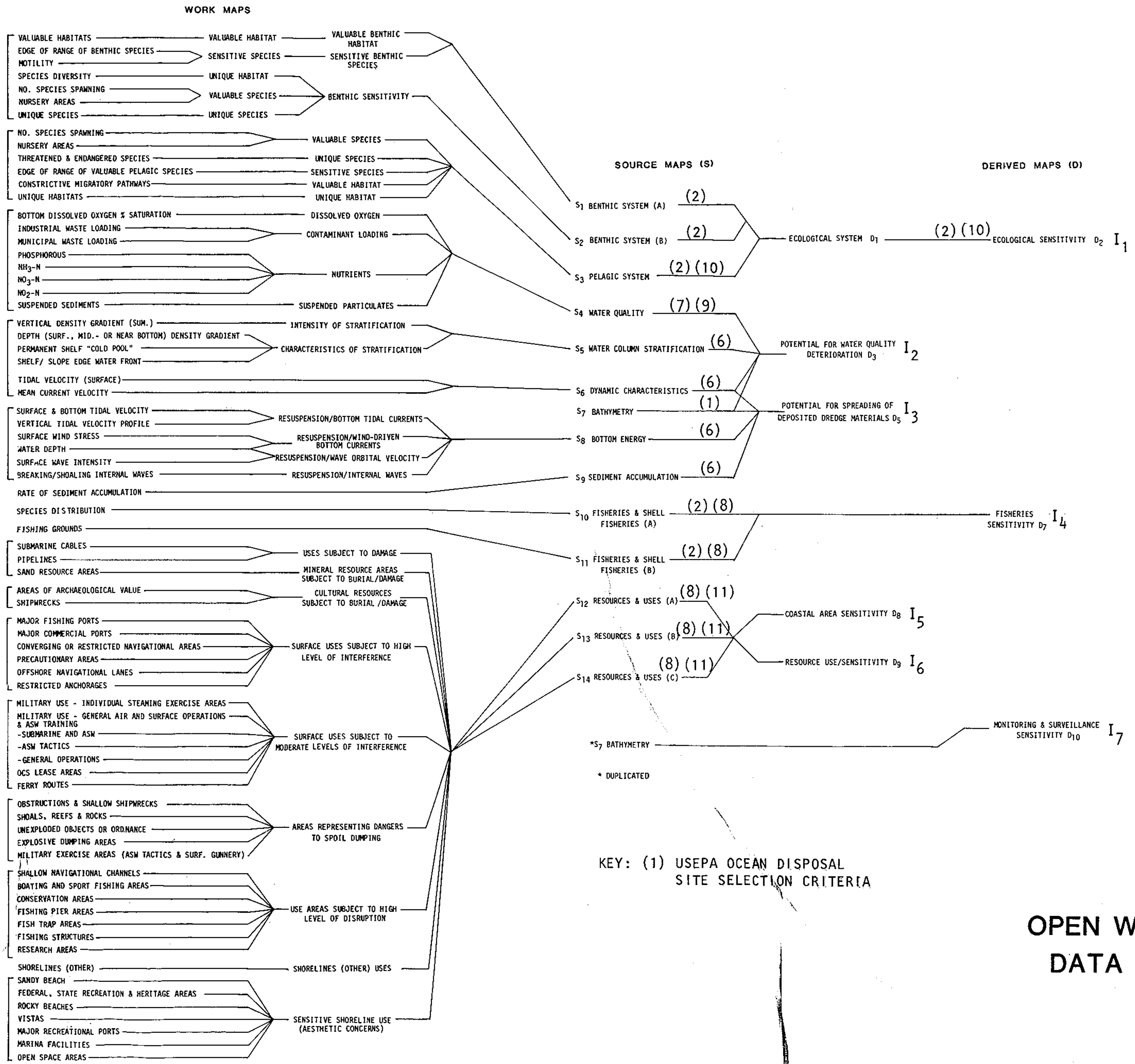
1) Geographic position, depth of water, bottom topography and distance from coast;
2) Location in relation to breeding, spawning, nursery, feeding, or passage areas of living resources in adult or juvenile phases;
3) Location in relation to beaches and other amenity areas;
4) Types and quantities of wastes proposed to be disposed of, and proposed methods of release, including packing the wastes, if any;
5) Feasibility of surveillance and monitoring;
6) Dispersal, horizontal transport and vertical mixing characteristics of the area including prevailing current direction and velocity, if any;
7) Existence and effects of current and previous discharges and dumping in the area (including cumulative effects);
8) Interference with shipping, fishing, recreation, mineral extraction, desalination, fish and shellfish culture, areas of special scientific importance and other legitimate uses of the ocean;
9) The existing water quality and ecology of the site as determined by available data or by trend assessment of baseline surveys;
10) Potential for the development or recruitment of nuisance species in the disposal site;
11) Existence at or proximity to the site of any significant natural or cultural features of historical importance.

The ocean dumping guidelines have been used even though they do not necessarily apply throughout the study area (see Section I.C for discussion of Section 404 and Section 103 requirements and areas of application). These guidelines represent a comprehensive checklist regarding the environmental factors to be considered in selecting open water disposal sites irrespective of their actual location. Similar concerns are expressed in the recently released 404 (b)(1) guidelines (44 FR 54222).

All of these criteria were incorporated at various points in the site selection/evaluation process. Certain of the EPA criteria are considered in greater depth in other portions of this study. For example, Criterion (4), which considers the quantity and characteristics of the dredged material as well as the means of deposition, is dealt with in the site management analysis section of this report.

II.B.2 Suitability Analysis Methodology

The analysis procedure is outlined by the Data Structure Diagram (Figure II.B-1). This diagram schematically shows the data flow through the study. Basic data, as shown on the far left of the diagram, are contained in the source data and work maps. The series of environmental evaluations made throughout the analysis are schematically shown as junctions in data pathways. The results of these evaluations are themselves maps which qualify conditions based on values of several environmental parameters. These intermediate maps are further evaluated and combined to represent major impact categories or siting issues. The data structure diagram is keyed to show where the 11 ocean dumping criteria (Section II.B.1) have been applied.



OPEN WATER DISPOSAL STUDY DATA STRUCTURE DIAGRAM

FIGURE II.B-1

In all, the data structure diagram shows the four levels of analysis or map types used in the study: work maps, source data maps, derived/issue maps and environmental suitability maps.

- o Work Maps are manually prepared maps showing the distribution of strictly defined data classes such as fishing grounds, tidal currents, nutrient loadings, etc.
- o Source Data Maps are combinations of Work Maps into more generalized discipline level maps, which describe:

  - Benthic System
  - Pelagic System
  - Stratification
  - Water Quality
  - Dynamic Characteristics
  - Bathymetry
  - Bottom Energy
  - Sediment Accumulation
  - Fisheries & Shellfisheries
  - Resources & Uses

  Source data maps are designated by numbers with an S prefix on the Data Structure Diagram (Figure II.B-1).

- o Derived/Issue Maps are the results of environmental evaluations on the stored map data (Source Data Maps or other Derived Maps). These maps are interpretive in that they are based on discipline knowledge of the relationships between input data maps. Derived maps may represent intermediate analysis steps, as in the case of the ecological system map. Such maps are designated by numbers with a D prefix on the data structure diagram (Figure II.B-1). A derived map may also represent a category of major concern. These derived maps are designated as issue maps and are shown on the Data Structure Diagram by numbers with an I prefix.

  - Ecological System
  - Ecological Sensitivity
  - Potential for Water Quality Deterioration
  - Potential for Spreading of Deposited Dredged Materials
  - Fisheries Sensitivity
  - Coastal Area Sensitivity
  - Resources and Uses Sensitivity
  - Monitoring and Surveillance Sensitivity

- o Environmental Suitability Maps are composite maps created by overlay of the issue maps. A value setting process was employed to accomplish the trade-off analysis to determine the relative importance of the issues. The relative importance of the issues was then used to produce the composite environmental suitability map.

The environmental suitability analysis used Dames & Moore's Geographic-Based Information Management System, GIMS®, as a basic analysis tool. GIMS is a computer-based mapping system which provides for a wide range of options in storage, manipulation and display of spatially disposed data. It allows for the evaluation of map data through incorporation of a large number of considerations.

During data analysis, it is possible to aggregate a number of judgments, made by various disciplines, into an integrated set of evaluations. These evaluations serve as the basis for identifying the most environmentally suitable (or least environmentally unsuitable) areas for open water disposal.

A detailed discussion of the terminology, data sources, mapping procedures and analysis techniques used in going from the work maps through to the environmental suitability map appears in Appendix A.

II.B.3. Rating of the Issues

In conducting a study such as this one, it becomes necessary at some point to make evaluations at a multidisciplinary level. Such evaluations can become exercises in identifying optimum conditions given a number of factors with opposing or complicated interrelationships. Evaluations of this nature are more appropriately made by a group representing a broad base of interests and expertise.

The method used during this study was a modification of the Delphi method, in which a group of 20-25 people representing a broad range of interest in and knowledge of the topic at hand a) are assembled at a central location; b) hear an explanation of the issues they are to discuss and how those issues were derived; and c) rate the importance of the issues (importance ratios). All of the participants' rating sheets are collected, normalized, and the results of the first iteration are posted. Each participant learns at that point what the group consensus was and how his or her own importance ratios compared to the group's values. The floor is then opened to discussion, during which participants can explore the issues further and/or try to convince other participants to change their importance ratios. When all participants have had a chance to participate, the issues are rated again. The rating sheets are collected and normalized, and the results posted again. Generally, two to three iterations are required before group stability is achieved. (Group stability means only that there is no further significant change in the group's results.)

The value setting process for this study was run over a two-day period, with members of the scientific community, staffs of the Corps of Engineers and Dames & Moore and representatives of some regulatory agencies participating. A data structure diagram was presented and served as an outline for the discussion. After extensive discussion, the data structure diagram was modified to its present form (Figure II.B-1) and the value setting process began. The importance of the final issues was determined by that process to be:

	Final Issue	Importance (%)
I-1	Ecological Sensitivity	25.0
I-4	Fisheries Sensitivity	22.0
I-3	Potential for Spreading of Deposited Dredged Materials	17.0
I-7	Monitoring & Surveillance Sensitivity	13.0
I-2	Potential for Water Quality Deterioration	12.0
I-6	Non-Living Resource Sensitivity	5.5
I-5	Coastal Area Sensitivity	5.0

Issues I-5 and I-6 were given low weights by the group with the understanding that certain areas would be restricted from consideration for disposal. These include pipeline and cable areas, conservation areas, and areas within 2 kilometers of shore.

Issue I-2 was reduced in value by the group based on the understanding that only materials which pass the appropriate regulatory criteria and testing procedures would be considered for open water disposal.

Issue maps for the Long Island-Block Island Sound area are shown in the following figures:

Figure II.B-2 — Ecological Sensitivity
Figure II.B-3 — Potential for Water Quality Deterioration
Figure II.B-4 — Potential for Spreading of Deposited Dredged Materials
Figure II.B-5 — Fisheries Sensitivity

Non-living resources/uses which occur in the vicinity of Candidate Site areas are shown on the specific site area maps (Figures III.B-1 through III.B-11). Coastal area sensitivity and monitoring and surveillance sensitivity maps were formulated to differentiate between near shore and continental shelf areas. As such, significant differences in sensitivity are not shown in the Long Island Sound-Block Island Sound region of these maps. They have not been reproduced here for this reason.

The Environmental Suitability Map (Figure II.B-6) is developed as an overlay of issue maps weighted in proportion to their importance ratios. It shows the distribution of relative suitability throughout the study area. The map can be used directly to select areas which would result in the least environmental impact.

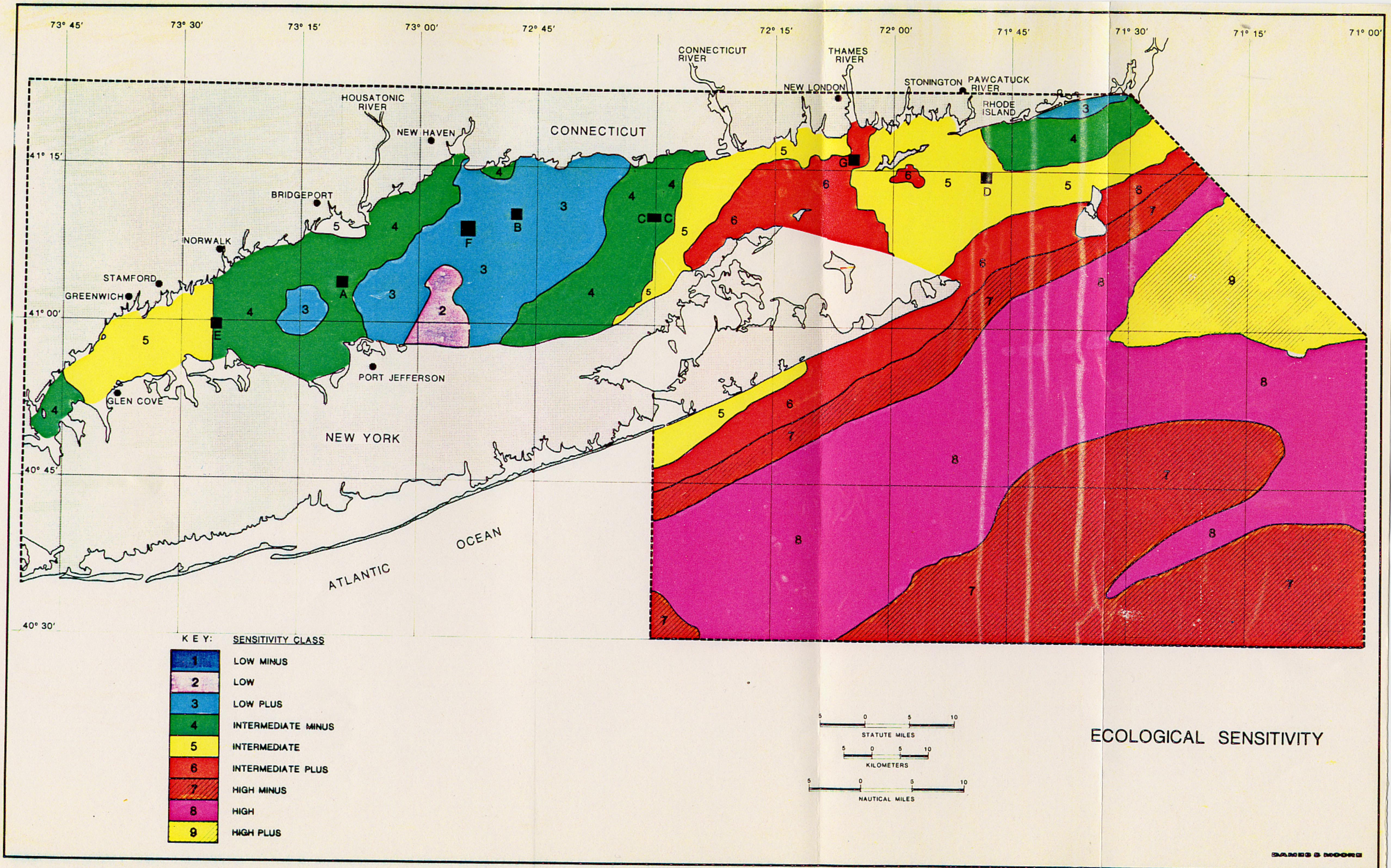
The suitability classes represent nine equal divisions in the range of total scores or ratings. Areas falling into the "high plus" class of suitability ranked best with respect to the environmental considerations evaluated in the analysis. Areas falling into the "low minus" class ranked worst. The Environmental Suitability Map, therefore, identifies the areas which on the basis of the study-area-wide screening, appear to offer the best possibilities for location of low-environmental-impact disposal sites.

II.C Selection of Candidate Site Areas

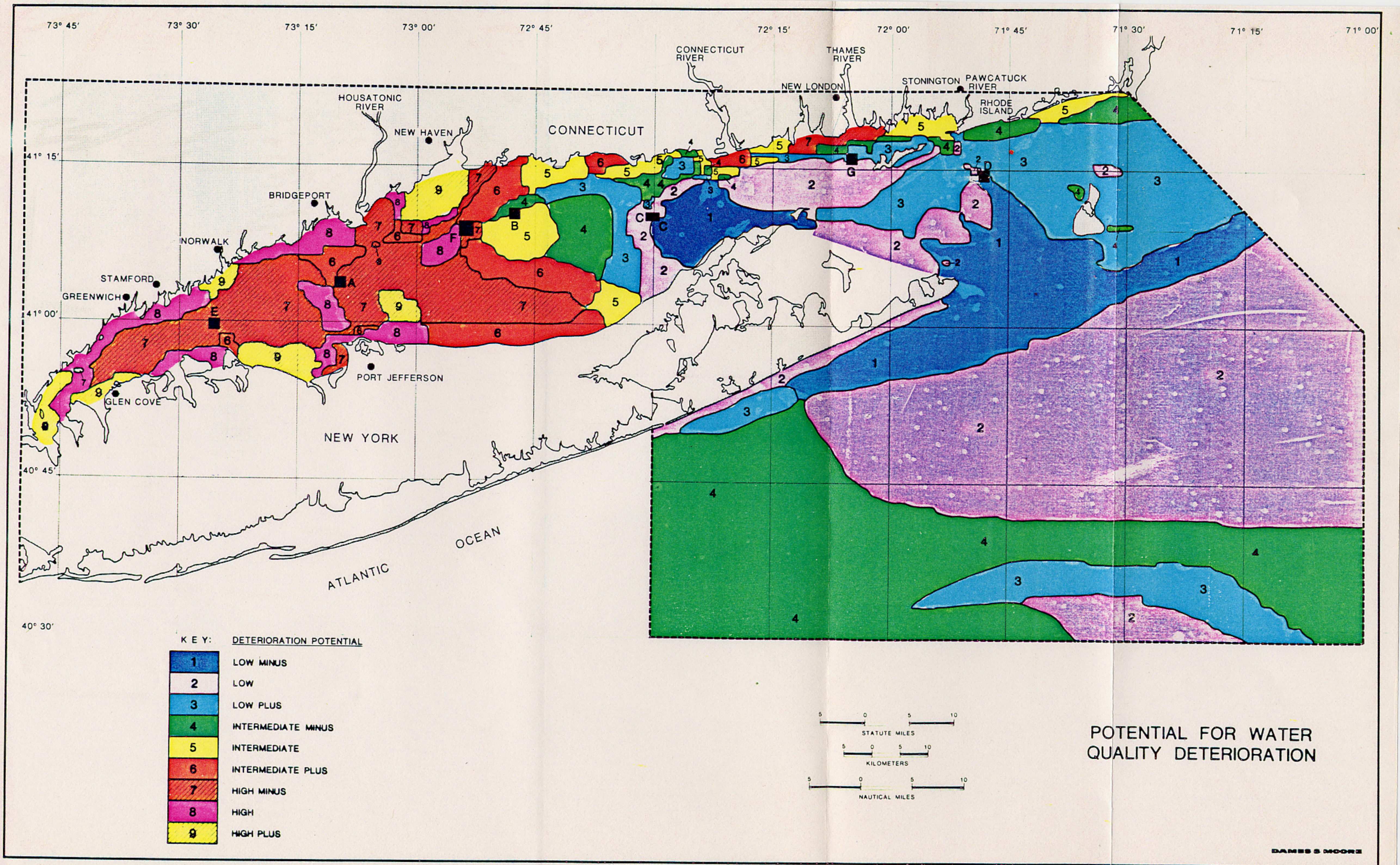
Candidate site areas are those areas which were selected for closer evaluation and impact assessment. The selection was based on consideration of the environmental factors as expressed by the Environmental Suitability Map, the location of significant sources of dredged material and their projected volumes as well as regulatory and other factors raised in discussions with the Inter-Agency Dredging Management Work Group.

The Environmental Suitability Map (Figure II.B-6) shows that the most suitable areas for open water disposal (suitability class high plus) occur in a broad area of the Outer Continental Shelf starting approximately 130 kilometers south of Block Island and in a smaller area in Central Long Island Sound approximately 10 kilometers southeast of the Outer New Haven Harbor. Additional suitable areas (suitability classes high and high minus) occur throughout Central Long Island Sound and in smaller areas of Eastern and Western Long Island Sound and Block Island Sound. Areas of comparable suitability (high minus) are not encountered on the Continental Shelf closer than 75 kilometers south of Block Island.

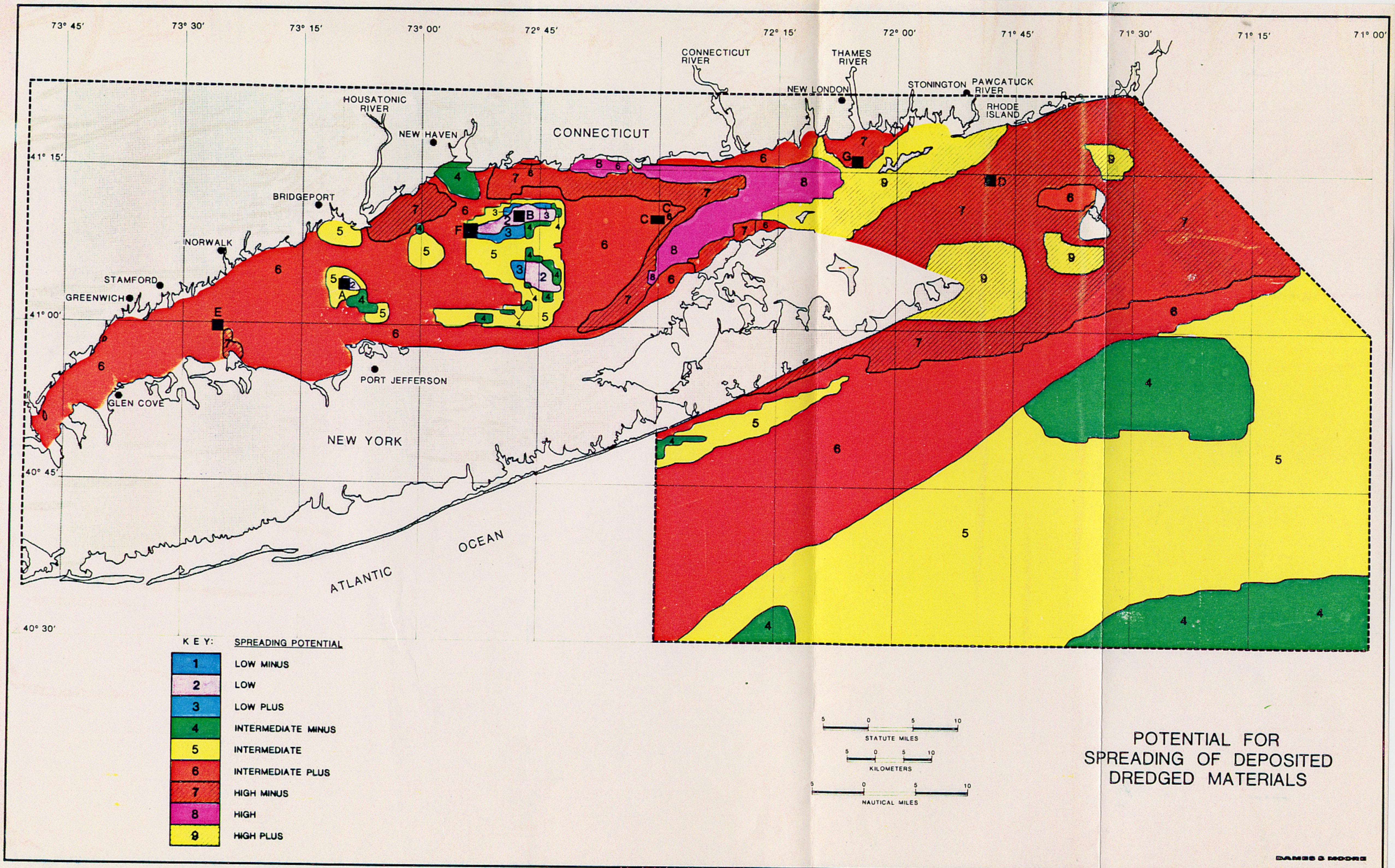
Significant economic costs would be incurred with the designation of distant sites on the Continental Shelf. A discussion of the economic impacts of the



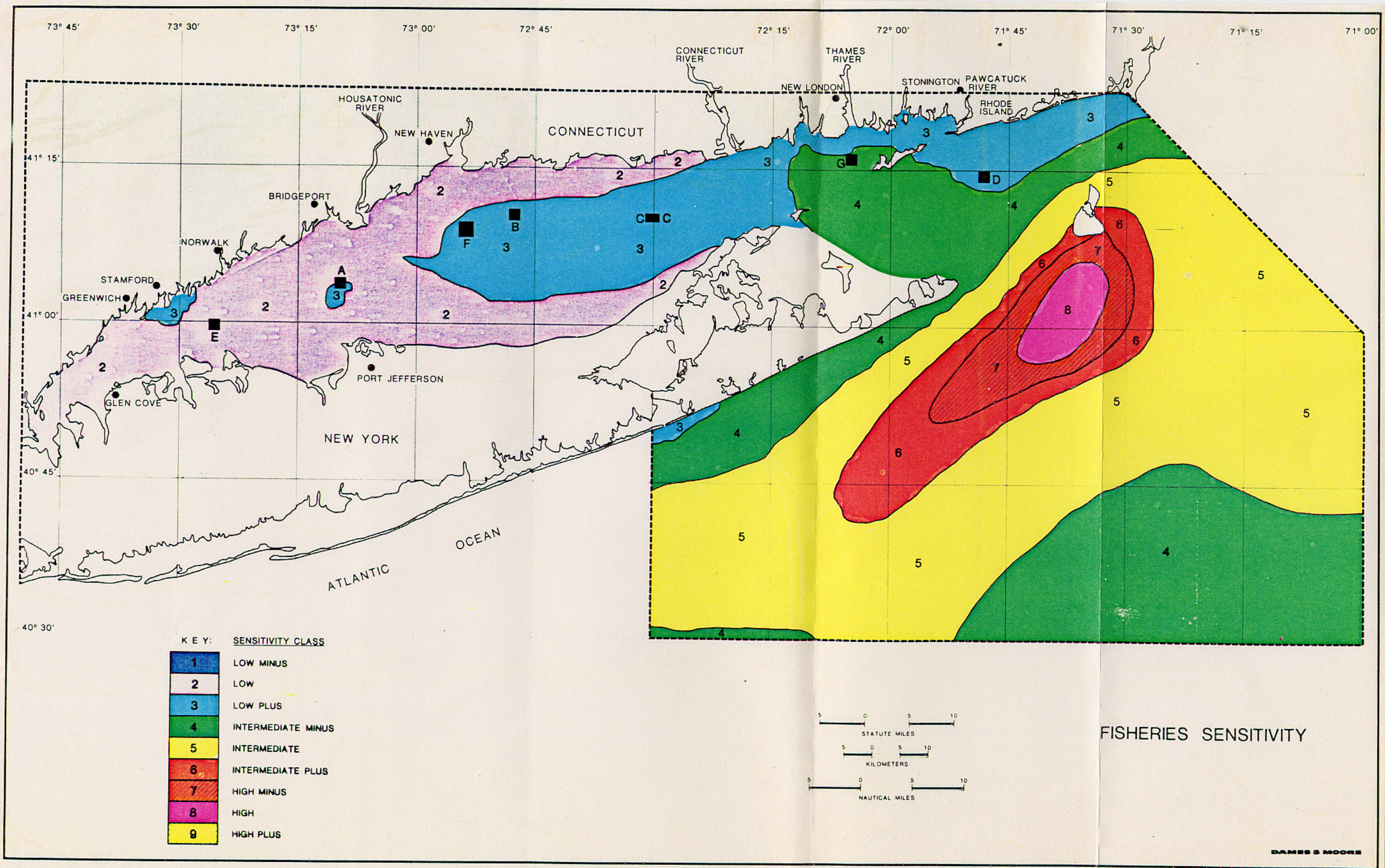
ECOLOGICAL SENSITIVITY

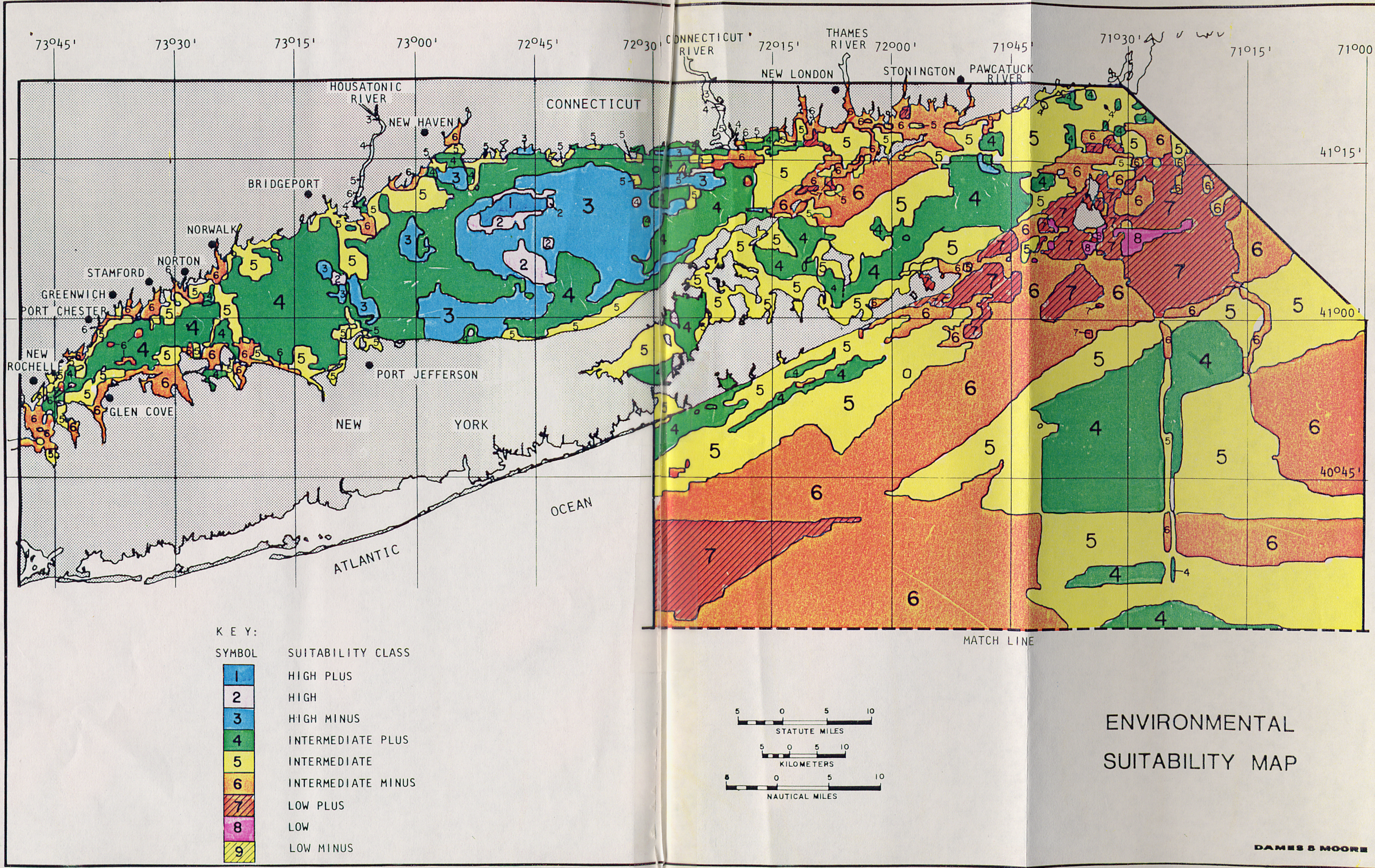


POTENTIAL FOR WATER QUALITY DETERIORATION



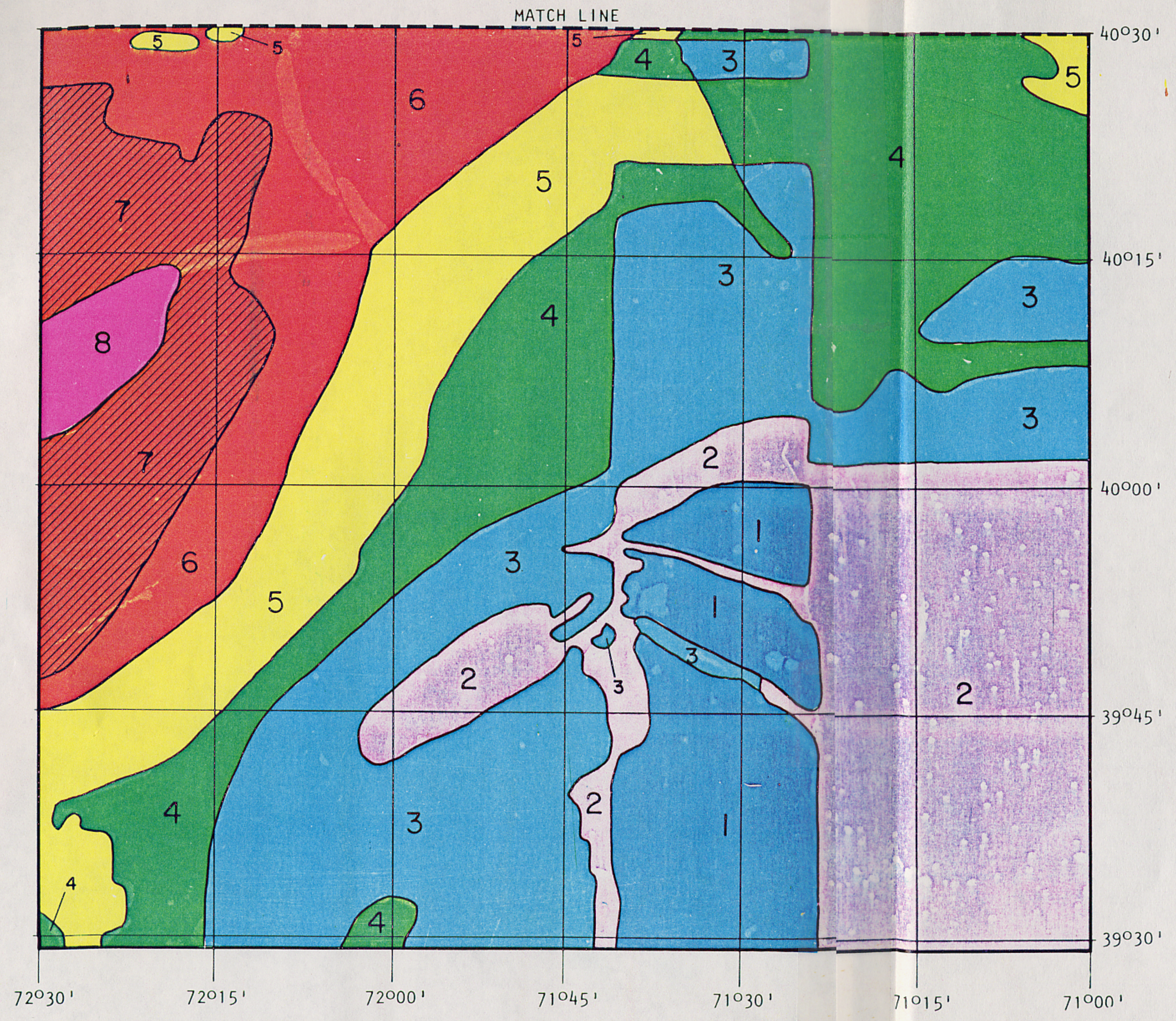
POTENTIAL FOR SPREADING OF DEPOSITED DREDGED MATERIALS


73° 45'
73° 30'
73° 15'
73° 00'
72° 45'
72° 15'
72° 00'
71° 45'
71° 30'
71° 15'
71° 00'
41° 15'
41° 00'
40° 45'
40° 30'
CONNECTICUT RIVER
THAMES RIVER
NEW LONDON
STONINGTON
PAWCATUCK RIVER
RHODE ISLAND
HOUSATONIC RIVER
NEW HAVEN
CONNECTICUT
BRIDGEPORT
NORWALK
STAMFORD
GREENWICH
GLEN COVE
PORT JEFFERSON
NEW YORK
ATLANTIC OCEAN
A
B
C
D
E
F
G
KEY: SENSITIVITY CLASS
1 LOW MINUS
2 LOW
3 LOW PLUS
4 INTERMEDIATE MINUS
5 INTERMEDIATE
6 INTERMEDIATE PLUS
7 HIGH MINUS
8 HIGH
9 HIGH PLUS
STATUTE MILES
KILOMETERS
NAUTICAL MILES
FISHERIES SENSITIVITY
DAMES & MOORE



ENVIRONMENTAL SUITABILITY MAP

FIGURE II.B-6



K E Y:

SYMBOL	SUITABILITY CLASS
1	HIGH PLUS
2	HIGH
3	HIGH MINUS
4	INTERMEDIATE PLUS
5	INTERMEDIATE
6	INTERMEDIATE MINUS
7	LOW PLUS
8	LOW
9	LOW MINUS

ENVIRONMENTAL SUITABILITY MAP

DAMES & MOORE

FIGURE II.B-6

use of such a site is provided in Section IV.M. However, the regional screening represented by the Environmental Suitability Map shows that areas in Long Island Sound are comparable to the distant shelf areas in terms of expected environmental impacts (same suitability class rating). Since there is no environmental advantage and a significant economic disadvantage to use of Outer Continental Shelf sites, they were not recommended for further evaluation as candiate site areas.

Within the Sound, the locations of the major sources of dredged material were plotted. Sites within the areas of highest environmental suitability which are proximate to the major sources were identified. This procedure identified four site areas (Sites A, B, C, D) within the Long Island Sound region.

Site Area A is centered around a small area of suitability located off Bridgeport Harbor. It represents the most environmentally suitable area in western Long Island Sound, and includes portions of the old Bridgeport site. Major dredged material sources in this area include the Housatonic River projects and Bridgeport Harbor.

Site Area B is located in the Central Sound area and includes the abandoned Branford disposal site.

Site Area C is centered in an area offshore from Clinton Harbor and within reasonable distance of the Connecticut River sources of dredged materials.

Site Area D is located in Block Island Sound at the Connecticut-Rhode Island border (Pawcatuck River).

Discussions were then held with the Dredging Management Work Group of NERBC concerning the site identification. That group includes representatives from the Environmental Protection Agency, the Coast Guard, the Corps of Engineers, the National Marine Fisheries Service, the Fish and Wildlife Service, the Interstate Sanitation Commission, the Connecticut Department of Environmental Protection, the New York State Department of Environmental Conservation and the State of Rhode Island. In response to the Dredging Management Work Group's suggestion for inclusion of a site area for impact assessment from within Western Long Island Sound in the Norwalk to Stamford region, Site Area E was selected. This area represents the most suitable area within the broad class of suitability which characterizes that part of the western Sound and includes a portion of the abandoned Eatons Neck Disposal Site.

In addition to these site areas (A, B, C, D, and E), the present New London and New Haven Disposal Sites, F and G, respectively, were included in the impact evaluation to provide a comparison between these existing sites and site areas A, B, C, D and E. The New London and New Haven sites are also sites recommended as disposal areas under the draft Interim Plan.

Prior to the assessment of the impacts of open water disposal of dredged material at the candidate areas, an additional refinement in site selection was performed. The local area of highest environmental suitability was examined with respect to biological, cultural, economic and resource use characteristics. The location of site boundaries was set to minimize the impacts on the local level as well as to maximize the site's capacity for dredged material. A discussion of these local siting considerations is provided in Section III.B.

The candidate sites described above and in Table II.C-1 have been evaluated with regard to the assessment of impacts associated with open water disposal of dredged material. The descriptions of the affected areas are presented in Section III. The impact evaluation conducted in Section IV is summarized together with appropriate mitigating measures in Table II.C-2. A detailed discussion is provided in Sections IV and V.

TABLE II.C-1

CLASSIFICATION OF SITES BY
ENVIRONMENTAL SUITABILITY CLASSES

Site	Suitability Class	General Offshore Location and Comment
A	2 and 3	Bridgeport, CT; includes portion of old Bridgeport site, western Long Island Sound
B	1	Branford, CT; central Long Island Sound, includes old Branford Site
C	2 and 3	Clinton, CT; east central Long Island Sound
D	3	Pawcatuk River, CT and RI; western Block Island Sound
E	4 and 5	Eatons Neck East, CT; western Long Island Sound
F	2 and 3	New Haven, CT; central Long Island Sound
G	4 and 5	New London, CT; eastern Long Island Sound

TABLE II.C-2

SUMMARY OF IMPACTS AND MITIGATIVE MEASURES FOR CANDIDATE SITES

Candidate Sites	Short-Term Water Column Effects	Short-Term Physical Effects on Benthos	Long-Term Effects on Aquatic Ecosystem Due to Chemical Contamination
A. Bridgeport East			
Impacts	Potential problem of summer oxygen depletion and potential for nitrogen release to stimulate agal blooms	Low to Moderate	Low (for contaminants) Moderate for oxygen depletion
Mitigative Measures	Limit disposal to cool periods when low bottom D.O. not present	Avoid disposal during spawning periods	Capping highly contaminated materials with clean cover; capping of high oxygen demanding materials
B. Branford			
Impacts	Not Significant	Low	Low (Confinement site)
Mitigating Measures	N.A.	Avoid disposal during spawning periods	Capping of highly contaminated materials with clean cover
C. Six Mile Reef			
Impacts	Not Significant	Moderate	High (Dispersal -ite)
Mitigating Measures	N.A.	Use of techniques for limiting area of bottom impact (increase bottom roughness and lower insertion speeds); Avoid disposal during spawning periods	Restrict disposal to clean materials (spread fine organics)
D. Block Island Sound			
Impacts	Not Significant	Moderate	Low-Moderate (Moderate confinement site)
Mitigating Measures	N.A.	Use of techniques for limiting area of bottom impact (increase bottom roughness and lower insertion speeds); Avoid disposal during spawning periods	Capping of moderately to highly contaminated material with clean cover
E. Eatons Neck East			
Impacts	Potential problem of summer oxygen depletion and potential for nitrogen release to stimulate agal blooms	High	Low for contaminants (Confinement site) moderate for oxygen depletion
Mitigating Measures	Limit disposal to cool periods when low bottom D.O. not present	Avoid disposal during spawning periods	Capping highly contaminant materials with clean cover; capping of high oxygen demanding materials
F. New Haven			
Impacts	Not Significant	Low	Low (Confinement site)
Mitigating Measures	N.A.	Avoid disposal during spawning periods	Capping of highly contaminated materials with clean cover
G. New London			
Impacts	Not Significant	Low	Low-Moderate (Moderate confinement site)
Mitigating Measures	N.A.	Avoid disposal during spawning periods	Capping of moderately to highly contaminated materials with clean cover

III. THE AFFECTED ENVIRONMENT

III.A Regional Characteristics

III.A.1 Bathymetry and Sediments

Long Island Sound was created during the last major continental glacial age, which climaxed roughly 15,000 years ago. It is thus a geologically youthful feature. Long Island is formed of several terminal moraines that mark the southernmost extension of the ice sheets which covered and sculpted the New England bedrock that now forms the northern shore of the Sound.

The floor of Long Island Sound has been classified on the basis of bottom relief into three general physiographic provinces; the western, central and eastern basins (Koppelman et al., 1976). The western basin is characterized by few tributaries, irregular relief, and shallow depths. The bottom sediments are predominantly muds, and the basin is joined to the deeper central province by a narrow gap in the Stratford Shoals, the boundary between them. The central basin, largest of the three provinces, displays a smooth bottom that slopes gently to the south. Average depths are about 30 meters, and basin floor sediments are dominated by muds. The boundary between this basin and the irregular eastern basin is provided by the Mattituck Sill, a gravel ridge running between Duck Pond Point on Long Island and Hammonaset Point in Connecticut. This feature in part restricts circulation in the deeper portions of the central basin. The eastern basin, which in places is as much as 100 meters deep, has highly irregular bottom relief as a result of the strong currents passing between Long Island Sound and Block Island Sound to the east. The currents also account for the coarse nature of the sediments, which are best described as a lag deposit, a result of the winnowing away of fine material by turbulent flow.

The floor of inner Block Island Sound is characterized by highly irregular relief. Due to the open exposure to the southern New England shelf, wave and current effects are much more pronounced than in Long Island Sound. Bottom sediments reflect this higher energy environment with sands, gravels, and cobbles being common throughout the inner Block Island Sound. Further south, in deeper water, the bottom becomes quite smooth and finer grained, and current magnitudes become reduced.

III.A.2 Circulation and Hydrography

Water motion in Long Island Sound is dominated by tidal currents acting through the two points of exchange with the Atlantic Ocean. By far the strongest currents are found in the area of The Race, between Block and Long Island Sounds and at Six Mile Reef. The three-dimensional circulation is an estuarine Type B pattern (Pritchard, 1969) in which a westward spread of cool, saline bottom waters enters from Block Island Sound and moves down the long axis of the Sound. Surface currents generally run from west to east as a result of prevailing winds and the balance of motion required by the westerly flow of bottom waters.

Block Island Sound circulation is largely controlled by tidal currents augmented by wind-driven flow. Unlike Long Island Sound, which displays varying degrees of stratification, Block Island Sound has a fairly well-mixed water column.

General circulation consists of the eastward-flowing surface waters which leave Long Island Sound and spread out over Block Island Sound waters. The greatest flow then veers south and west around Montauk Point to form a coastal current along the southern shore of Long Island.

Temperature and salinity (T-S) vary widely both in space and time. In general, Block Island Sound displays T-S values typical of the shallow Southern New England continental shelf. Once into Long Island Sound, however, the two-layer estuarine situation becomes more dominant as one moves westward. Salinities change from about 30o/oo (parts per thousand) to 20o/oo in the East River. However, directly off several tributaries (Housatonic, Thames and Connecticut Rivers) salinities of surface water may fall below 20o/oo. The deeper waters retain higher salinity values and lower temperatures as they move westward through Long Island Sound.

Seasonal temperature fluctuations are more of a factor in density stratification than salinity. The differences in surface temperatures between summer and winter approach $20^{\circ}C$, while bottom waters generally show only half of this variation. Density differences generated by changes in T-S relationships are maximized during the warm summer months, reaching a peak in August. Density difference minima are reached during the winter months of December and January. Various factors such as strong tidal currents, irregular topography and wind and tidal mixing work to diminish or eliminate stratification.

III.A.3 Biology

III.A.3.a Phytoplankton

The phytoplankton in Long Island Sound and the physical and chemical characteristics that influence their abundance and distribution have been well studied. Long Island Sound current flows exhibit 3 main eddies: a) counterclockwise in the west, b) clockwise in the central sound, and c) counterclockwise in the east. There is a net eastward flow out of the Sound with a compensating inward bottom flow. This two-layered transport system in Long Island Sound allows nutrients to be retained and helps maintain a nutrient supply a bit higher than that found in adjacent waters.

Phosphate and nitrate levels exhibit seasonal cycles similar to those that occur in temperate open coastal waters. Large regional differences are not readily identifiable; however, there may be differences in maximum concentrations at times. Overall the concentrations of phosphate and nitrate decrease from west to east. Ammonia and dissolved organic nitrogen exhibit similar west to east gradients (Harris, 1959). Observed west to east differences for phosphate and nitrate have been 3.0, 2.2, and 1.0 μ moles/l, and 15.0, 9.0, and 6.0 μ moles/l respectively. Observed seasonal cycles have been attributed to phytoplankton use, excretion, regeneration and enrichment.

The phytoplankton in Long Island Sound exhibit regional and seasonal differences similar to those found for nutrients. A major bloom occurs in winter between January and March and is regulated by light and temperature. This bloom almost exhausts the nitrate concentration in three to four weeks and is just about depleted afterward until an increase in the fall. Minor blooms occur during the spring and summer. The magnitude of this flowering depends upon available inorganic nitrogen and vernal temperatures. An autumn flowering, a result of strong vertical mixing may occur and is followed by very low growth until the late winter bloom

(TRIGOM, 1974). The cycle in Long Island Sound is similar to those in New England with differences in phytoplankton abundance, composition and timing. Diatoms, dinoflagellates,and silicoflagellates are yearly dominants with diatoms and silicoflagellates exhibiting a winter maximum and dinoflagellates abundant during the summer.

About 200 species of phytoplankton have been reported in Long Island Sound, of which 40 are major constituents. The species composition is basically a mixture of temperate and boreal species with littoral and neritic tendencies. Listings of Long Island Sound phytoplankton can be found in Conover (1956) Riley and Conover (1967) Riley (1967) TRIGOM (1974) and Nuzzi (1977).

Riley (1952) describes the phytoplankton in Block Island Sound. There is a minor spring bloom in February-March followed by a moderately large population in late summer. This is typical of coastal temperate waters (TRIGOM, 1974). The population is dominated by a single diatom (83 percent of population is Skeletonema costatum (TRIGOM, 1974)). Riley (1952) concluded that neither zooplankton grazing nor phosphate cycle was important. Block Island Sound probably produces more phytoplankton than is consumed, with the excess taken to the southeast by physical dispersal.

The net annual production for Long Island Sound is 205 gC/m^2, compared with 285 gC/m^2 and 100-160 gC/m^2 for Block Island Sound and the continental shelf respectively. Daily production of phytoplankton is about seven percent of the standing crop. Of this 4.5-6.0 percent are consumed daily by zooplankton. Therefore, even though the production rate is high, the consumption rate is also high so that a balanced system with little variation in population levels results. Sporadic pulses do, however, occur in May and June when consumption does not keep up with production. The high primary production is utilized by a great number of small animals and thus the Sound is relatively inefficient in the production of both groundfish and carnivorous invertebrate epifauna as compared to Block Island Sound, Georges Bank and the English Channel (Riley, 1956).

III.A.3.b Zooplankton

Zooplankton can be subdivided into three groups: (a) holoplankton, which spend their entire life cycles in the water column; (b) meroplankton, which spend only a portion of their life cycles as plankton; and (c) tychoplankton, which are accidentally swept off the bottom. The major abiotic factors limiting the production and dispersal of estuarine zooplankton are temperature and salinity. Peak numbers of zooplankton produced annually are usually observed following the seasonal phytoplankton flowering described above.

The copepods Acartia clausi and A. tonsa are dominant throughout most of the year. A. clausi is the dominant zooplankton species from January to May and A. tonsa is dominant from July to September. Deevey (1956) reported Temora longicornis as the dominant zooplankton species in June and Oithona spp. were dominant from September to December. Listings of other major zooplankton species in Long Island Sound and Block Island Sound can be found in Deevey (1952a, b) Conover (1956) TRIGOM (1974) and Caplan (1977).

Acartia spp. are relatively inefficient feeders and are not important elements in the dynamics of the phytoplankton population in Long Island Sound (Riley,1956). Conover (1956) found that nutrient depletion was much more important than grazing by zooplankton in regulating the phytoplankton population after spring blooms in Long Island Sound. Ryther (1954) observed that zooplankton grazing in a nutrient-rich fertilized area of Moriches Bay did not have much effect on phytoplankton populations composed mainly of small flagellates. Two estimates of standing crop of Long Island Sound zooplankton are given in Table III.A -1.

III.A.3.c Benthos

Long Island Sound supports an assemblage of both mature and immature forms of benthic invertebrates made up mainly of polychaetes, amphipods and molluscs. The fauna are also classified by three major feeding types: deposit feeders (many polychaetes, amphipods, some decapods, and some pelecypods) that feed by ingesting the bottom sediments and digesting associated living or dead organic matter; suspension feeders (many molluscs, some polychaetes) that filter food particles from the water column; and predators (many decapods, polychaetes) that relatively consume other living animals. Most of these benthic organisms are prey for larger predators (crabs, lobster starfish and fish) that feed on or near the bottom. The distribution of these feeding types is governed mainly by different sediment compositions.

MAFC (1974) had identified four major bottom sediment types within Long Island Sound: a) fine deep-water sediments, generally 15-40 m depth and composed of more than 68 percent silt-clay; b) coarse shallow-water sediments, basically along the northern coast of Long Island, with water depths of 2-6 m and sediment grain sizes greater than or equal to 0.5 mm with less than 3 percent silt-clay; c) coarse deep-water sediments, medium to coarse sandy sediments on the Long Island coastline extending into waters 20-40 m in depth in the Mattituck Sill region and eastward; and, d) transitional shallow-water sediments, sediments intermediate in mean size and silt-clay content along the northern coast of the Sound. The benthic organisms found in each of these zones vary in species composition, abundance and species diversity.

Fine Deep-Water Sediment Associations

The biologic community in fine deep-water sediments is characterized by a polychaete-bivalve community (MAFC, 1974) which is similar to the polychaete-bivalve community described by Sanders (1956) in level soft-bottom sediments. Major components of this zone are gastropods and other species of polychaetes and bivalves.

Relative values of benthic species abundance (diversity) of the groups in the fine deep-water sediments range from low to moderate. The upper limit group is located in the eastern basin of Long Island Sound where the sediments are fine with 28-70 percent silt-clay content. Diversity here is significantly higher than in the western groups of fine sediments. The difference is due largely to lowered dominance (MAFC, 1974) and possibly an average decrease in the silt-clay component (most less that 68 percent). The lowest diversity occurs at a group of stations in a mid-Sound strip from east of Stamford to Execution Rock. Other low values were reported at 17 soft-bottom deep-water stations and for eight stations within a triangle between Port Jefferson, Bridgeport and Northport. Overall diversity values are appreciably lower than median diversities in a number of areas studied or reviewed by Boesch (1972). These studies indicate values relatively higher in the Chesapeake-York Estuary, Virginia's outer continental shelf and Hampton Roads. Species diversity is often used as an indicator of environmental stability. Low diversity may indicate highly stressed environments. However, some of the low diversity values obtained in western and central Long Island Sound are due to extreme dominance by several species, which can also be considered a sign of the area's productivity. Analysis of infauna indicates

TABLE III.A-1

STANDING CROP OF ZOOPLANKTON IN LONG ISLAND SOUND

	Riley, 1941[1]		Deevey, 1956[2]		
mesh	#20	#20	#10	#2	#10
unit	#/l	#/m³[3]	#/m³	μ l/m³[4]	μl/m³
Month					
January	3.6	3,600	10,635	180	260
February	8.8	8,800	19,560	200	370
March	27.8	27,800	35,808	300	1,210
April	45.8	45,800	48,842	800	1,030
May	—	—	94,035	240	1,155
June	60.2	60,200	161,385	200	1,120
July	60.4	60,400	77,000	180	1,000
August	109.4	109,400	114,715	600	3,370
September	60.9	60,900	105,140	220	2,700
October	8.5	8,500	31,180	170	230
November	5.6	5,600	31,350	50	240
December	—	—	14,325	100	210

(1) September 1938 - August 1939. Water samples.

(2) March 1952 - June 1953, Clarke Bumpus oblique tows, displacement volumes.

(3) Approximate conversion to numbers per cubic meter ($\#/m^3$) made by multiplying published numbers per liter by 1000.

(4) Displacement volumes reported by authors as ml/m^3 have been converted to $\mu l/m^3$ by multiplying values given by 1,000 ($1\ \mu l/m^3$ is roughly equivalent to $1\ mg/m^3$ on a wet weight basis).

higher diversities near uncontaminated portions of the Connecticut coast (MAFC, 1974).

Coarse Shallow-Water Sediment Associations

The coarse shallow-water sediment type is found at all the MAFC (1974) inshore stations from Manhasset Neck to Greenport in Long Island Sound. In this zone Nephtys picta had the greatest biomass of the polychaetes collected. Several polychaetes found here were also found in the deep soft-bottom areas. The surf clam was the most conspicuous mollusc. Many stations sampled contained 10 or more juvenile surf clams, with several having more than 100. The jacknife clam and the northern dwarf tellin occurred in greater abundance here than in the fine deep-water stations. The surf clam was not collected west of Northport whereas the clam and jacknife and a spionid and capitellid polychaetes increased to the west, possibly due to the increase in contaminant load to the west. Median diversity in this zone is low to moderate.

Coarse Deep-Water Sediment Associations

The coarse deep-water sediments are generally poorer in numbers of species and individuals than the coarse shallow area described above. However, the median diversity is greater than that in the soft sediments to the west. Species in this zone are more often similar to those found in the coarse inshore area than those of the fine deep areas. Polychaetes, gastropods bivalves, and amphipods are common.

Species common to both the fine deep and shallow sandy areas are also present here. They include polychaetes, gastropods, grass shrimp, rock crab and hermit crabs. Some species are only found east of the Mattituck Sill: they include molluscs, an amphipod, and the rock crab. East of the Sill region more boreal or oceanic forms are represented. No highly consistent faunal assemblages are apparent in this zone (MAFC, 1974).

Transitional Shallow-Water Sediment Associations

The transitional shallow-water sediments have a fauna intermediate between those of the deep mid-Sound and inshore Long Island areas. The diversity in this sediment type is low to moderate (MAFC, 1974). Organisms found in the deep soft sediments are found here, but with less frequency and abundance. Polychaetes gastropods and crustaceans common in the other zones described above are also common in this sediment type. Several polychaetes (all of which have been classified as stress tolerant, rapidly colonizing, opportunistic species) become more abundant in numbers from east to west.

Overall it appears that western Long Island Sound is more often dominated by polychaetes, many of which are typical stress-tolerant species. The abundance of species and individuals of molluscs and amphipods increases to the east.

Studies by Serafy (1973), D'Agostino and Colgate (1973) and Alexander and D'Agostino (1972) generally agree with the species distribution within different sediment types as reported by MAFC, (1974). Some differences do occur but are probably due to different sampling techniques and sediment sieve sizes. Though stress tolerant organisms were common, it did not appear that these organisms were considered the dominants. Certain stress-sensitive species (certain amphipods) were generally present although in lesser numbers (MAFC, 1974). The benthic fauna in Long

Island Sound appears to be less stressed than similarly affected areas such as Raritan Bay (McGrath, 1974) and some areas of the New York Bight (Pearce, 1972).

III.A.3.d Fisheries and Shellfisheries

Generally the fish occurring in Long Island Sound are small euryhaline species using the region year round; juvenile fishes that use the system as nursery grounds; or diadromous species that use the area to migrate to and from spawning grounds (TRIGOM, 1974). It is generally agreed that estuaries, sounds and embayments of the coastal western Atlantic Ocean provide varied habitats to support numerous marine species. Within Long Island Sound the distribution of fish species depends on both temperature and salinity. Fish species reported in Long Island Sound are found in Richards (1963), Wise (1974), TRIGOM (1974) and Serafy and others (1977). NERBC (1975) lists 61 of the more common finfish species in Long Island Sound of over 100 known to exist in the Sound.

Two species which remain in the Sound all year are the tautog and the blackback flounder. Other species appear in Long Island Sound in certain seasons. Most of these are summer migrants who appear in May and usually leave in October. Typical summer migrants are black sea bass, scup, northern puffer, menhaden, silver hake, red hake and butterfish.

The commercial finfishery in the Long Island Sound is small in comparison to Block Island and Rhode Island Sounds. There is a limited otter trawl industry, along with some trap, pound and gill netting in various areas of Long Island Sound. Lobstermen also trawl at times for lobster bait. The standing crop of demersal fish is less than that recorded in Block Island Sound. Riley (1955) suggests that the high organic content of the mud which is found in most sections of the Sound, and the inefficiency of zooplankton feeders are possible reasons why the Sound does not produce an abundance of fish of marketable size. Richards (1963) also identifies the relatively high densities of starfish, which are sufficient to successfully compete with fish and some invertebrates for feeding areas on the bottom, as a cause of reduced fisheries productivity.

Sport fishing is usually concentrated around ledges, shoals, banks, and other places where habitat and water depth changes induce fish to congregate. Major species sought by the recreational industry are winter flounder, fluke, striped bass, bluefish, tautog and cunner.

The shellfisheries of Long Island Sound with the exception of the lobster fishery are generally near shore resources. They consist of species such as oyster, bay and sea scallop, bay and ocean quahog, mussels, crabs and conch. The lobster fishery is economically the most important shell fishery in Long Island Sound. Total value in 1978 was over $2 million (Connecticut DEP, 1979). Their distribution is indicated in NERBC, 1975 and basically covers all of western Long Island Sound and the central area of central and eastern Long Island Sound. Densities and landings are greatest in western Long Island Sound and decrease to the east towards Block Island Sound. Lobsters are taken with baited lobster pots (traps) set out and marked by buoys and retreived up to several days later. Lobsters prefer areas which provide shelter, however in flat sandy areas they may burrow and construct their own shelter. Both Connecticut and New York experienced increases in the total number of licensed fisherman and increased landing from 1958 to 1969 (NERBC, 1975). Connecticut alone had 62,000 licensed pots in 1969. Management programs have been put into practice to control over exploitation of the lobster resource.

Oysters were always associated with Long Island and Long Island Sound. However the exceptionally large landings at the turn of the century have been drastically reduced through the 1950's. Since an increase in the early 1960's the oyster fishery has generally fluctuated from year to year (NERBC, 1975). Increases in oyster aquaculture programs have indicated continued management should be able to continually increase oyster yields. State and town-leased shellfish beds in New York and Connecticut approximate 6300 and 29,400 acres respectively (NERBC, 1975).

Another molluscan shellfish of importance would be the hard clam. Recent data indicate a decline in hard clam landings but hard clam values continue to rise (NERBC, 1975). Nearly 6 million pounds of hard clams were landed in the early 1960's with only just over 1 million pounds landed in 1971. As in other eastern states (i.e. New Jersey) the ocean quahog is being taken to replace diminishing surf clam stocks. Distribution and life history information of these two species are given in TRIGOM (1974). Populations are greatest in the eastern region of the study area.

Shellfisheries for scallops and soft clams have declined to the point of little importance commercially (NERBC, 1975). Data on their distribution, along with mussel and conch, whose fisheries have recently shown a general rise, can be found in NERBC, 1975; TRIGOM, 1974; and Connecticut DEP, 1978.

Crabs are the other crustacean shellfish of commercial importance. The blue crab can be found near shore and is basically an estuarine species. The species of rock crabs found are generally distributed in deeper more saline waters and are commonly taken in lobster catches. Distribution and life history data can be found in TRIGOM (1974).

III.A.3.e Threatened and Endangered Species

An endangered species is one whose overall survival in a particular region or locality is in jeopardy. Its peril may result from loss of habitat, change in habitat, over exploitation by man, predation, adverse interspecies competition, or disease. Unless an endangered species receives protective assistance, extinction may occur. A species may also be considered as threatened or rare if its population becomes notably decreased because of the development of any number of limiting factors leading to a deterioration of the environment. Species which fall into these categories and have the potential for occurrence in Long Island Sound are listed in Table III.A-2.

The shortnose sturgeon (Acipenser brevirostrum) is an endangered species which probably utilizes portions of Long Island Sound as it has been recorded in the Connecticut River (Shortnose Sturgeon Recovery Team, 1977). Since it is an anadromous species, it can be inferred that it enters coastal rivers to spawn, however very little is known about the details of its distributional habits.

The Hawksbill turtle, Leatherback, Atlantic Ridley, Green Turtle and Loggerhead Turtle are all sea turtles which may enter the Long Island Sound. They are normally found in tropical and subtropical waters. However, occasionally in their travel north they may wander into Long Island Sound. The Loggerhead Turtle, Green Turtle and Leatherback Turtle have been reported in rare occurrences along the Connecticut shore (Connecticut DEP, 1977).

Of the marine mammals listed in Table III.A.2, the finback whale and humpback whale are the most likely to occur near the coast. The whales are usually

TABLE III.A-2

ENDANGERED AND THREATENED SPECIES OF THE NORTH ATLANTIC STATES

Shortnose Sturgeon	Acipenser brevirostrum
Hawksbill Turtle	Eretmochelys imbricata
Leatherback Turtle	Dermochelys coriacea
Atlantic Ridley Turtle	Lepidoechelys kempii
Green Turtle	Chelenia mydas
Loggerhead Turtle	Caretta caretta
Blue Whale	Balenoptera musulus
Finback Whale	Balaenoptera physalus
Humpback Whale	Metapter novaeangliae
Right Whale	Balaena glacialis
Sei Whale	Balaenoptera borealis
Sperm Whale	Physeter macrocephalus
Bald Eagle	Haliaetus lecocephalus
Peregrine Falcon (Arctic)	Falco peregrinus tundrius
Peregrine Falcon (American)	Falco peregrinus anatum

Reference: Federal Register, 1979, Vol. 44, No. 12, Wed., Jan. 17, 1979, pp. 3636-3654.

seen at sea. However, on extremely rare occasions whales have been reported in the Sound, as in 1975 when a finback whale beached itself near Groton (Connecticut DEP, 1977). NERBC (1975) also identify the Atlantic Right whale as a species which might occasionally occur near the eastern end of the Sound.

The Southern Bald Eagle is another endangered species found around Long Island Sound. The Bald Eagle's range includes all of North America, with preferred habitat confined to the coastal zones, internal lakes, rivers and reservations, and along mountain ridges during migration. Population of this species has been declining steadily throughout its range. The most limiting factor is loss of habitat, primarily along waterfronts, due to clearing of the land for both human habitation and industrial development, and forestry practices such as clear-cutting operations and removal of old dead trees. Additionally causes include poisoning with such toxicants as pesticides and mercury; human disturbance and noise causing abandonment of nests; reduction of food sources by industrial effluents; electrocution on high voltage lines; and intentional or accidental killing of the birds. The Arctic and American Falcons are endangered migrant species which fly over the Sound area during the fall and spring. While most American Peregrine Falcons move down the interior of the United States, the major flyway of the Arctic Peregrine Falcon is along the east coast of the United States (Nature Conservancy, 1976). The falcons commonly use coastal barrier islands for feeding and resting during migration due to their remoteneess and extensive marshes, which provide vast feeding areas for the falcons, which prey primarily on ducks and other shorebirds. Neither the American nor Arctic Peregrine Falcons presently breed in the eastern United States, although F. peregrinus anatum formerly did.

Ospreys have been declining nationwide in recent years. Although not on the federal list of endangered or threatened species, this bird is on the Audubon Blue List (Arbib, 1977). The primary reasons for this species' decline is through loss of reproductive potential from pesticide poisoning and ingestion of other toxic substances. The cumulative effect of DDT and the industrial pollutant, PCB poses a serious threat to this species because they are concentrated in some species of it's basic food source, fish. The reduced use of DDT and other persistent pollutants have helped to re-establish some of the osprey populations. Illegal hunting of this species is also a problem in some coastal regions.

III.B Characteristics of Candidate Sites

After candidate disposal site areas were identified through the site selection process discussed in detail in Section II, a candidate site was selected using the methodology summarized here. Taking into account the issues listed below, the candidate sites were positioned:

- within the local area of highest environmental suitability;
- topographically for optimization of containment and capacity and to minimize encumbrance of shallow areas;
- to minimize effects on living resource areas (i.e. heavy shell fishing or lobster fishing areas, etc.).
- in or adjacent to existing or discontinued disposal sites to minimize impacts in previously undisturbed areas;
- away from known cultural resources or use conflict areas such as shipwrecks, cable areas, etc.; and
- minimize distance to nearest source areas of dredged material.

For uniformity, a one square nautical mile area has been designated for each candidate site.

In this section the pertinent physical characteristics of the Candidate Sites are presented. These descriptions form the basis for the assessment of impacts discussed in Section IV. The important characteristics of the Candidate Sites listed in Table III.B-1 and include the following categories of data:

- o Location
- o Regulatory Jurisdiction
- o Physical Dimensions/Character
- o Dredged Material Disposal History
- o Sediments/Sediment Quality
- o Waves Characteristics
- o Surface and Bottom Tidal Currents
- o Water Column Stratification
- o Water Quality
- o Site Use/Value
- o Site Capacity

In addition to this tabular summary, the signficant physical, benthic faunal, and fisheries characteristics of each Candidate Site are treated below in detail. Fisheries and benthic faunal data are primarily derived from the existing literature covering Long Island Sound. Except in cases where sampling stations coincide with candidate sites, the data presented are derived by extrapolation, or represent generalizations of distribution and range developed by the original author. The key data sources used in constructing Table III.B-1 and the relative quality of the data for each site are presented in Table III.B-2.

It should be noted that except for data at specific monitored disposal sites, data of bottom tidal currents is lacking. Vertical tidal current velocity data available at some existing sites in Long Island Sound (e.g. Eatons Neck, New Haven and a location at eastern Long Island Sound) have been generalized for the purpose of extrapolating the near-bottom tidal current velocity at the study sites as shown in Table III.B-1. Magnitudes of near-bottom tidal velocities obtained for the existing sites compare closely to the available bottom current velocity data obtained from field measurements.

Also, direct measurements of wave generated bottom currents in the study area are not available. Wave-induced bottom velocities have been estimated for the significant wave heights and periods at the study sites in the Sound (Table III.B-1). The significant wave heights and periods were obtained considering the longest effective fetch in the direction of wind approaching the sites, and the average maximum wind speed associated with that direction which usually occurs in the winter season (on the order of 20 to 22 knots). For Block Island Sound wave data from the Summary of Synoptic Meteorological Observation (U.S. Navy Weather Service Command, 1970) are used to estimate the average wave heights and periods of the highest 30 percent to 40 percent of the waves in the winter season. The significant wave heights and periods were interpolated and bottom wave induced velocities determined. Table III.B-1 summarizes the bottom current velocities generated by tides and waves at the study area.

Site capacity was estimated by calculating the volume of the frustrum of a pyramid whose rectangular base corresponds to the site boundaries. Sides of the

TABLE III.B-1

SELECTED CHARACTERISTICS FOR CANDIDATE DREDGED MATERIAL DISPOSAL SITES

SITE Selected Characteristics	A Bridgeport East	B Branford	C Six Mile Reef	D Block Island Sound	E Eatons Neck East	F New Haven	G New London
LOCATION							
Water Body	Long Island Sound	Long Island Sound	Long Island Sound	Block Island Sound	Long Island Sound	Long Island Sound	Long Island Sound
Latitude (N)	41°03.7'	41°10.3'	41°10.5'	41°14.5'	40°59.6'	41°08.9'	41°16.3'
Longitude (W)	73°09.7'	72°47.5'	72°30.5'	71°48.0'	73°25.0'	73°53.1'	72°04.6'
REGULATORY JURISDICTION							
State	Connecticut	Connecticut	Conn. & N.Y.	—	Connecticut	Connecticut	Connecticut
Army Corps of Engineers	New England Div.	New England Div.	New Eng. & N.Y. Dist.	New England Div.	New England Div.	New England Div.	New England Div.
USEPA	X	X	X	X	X	X	X
PHYSICAL DIMENSIONS/ CHARACTER							
Area	1 sq. nm	1 sq. nm	1 sq. nm	1 sq. nm	1 sq. nm	2 sq. nm	1 sq. nm
Depth Range (meters)	21-25	18-23	15-33	31-34	15-58	15-23	14-25
Average Depth (meters)	23	20	25	32	45	20	20
Bottom Contour	Gentle slope to S.	Smooth gentle S.E. slope	E-W depression with steep north flank	Flat NW-SE trending ridge	Deep WSW-ENE depression	Smooth gentle slope, spoil mound in north central area	Shallow depression, spoil mounds in N and S central areas
DREDGED MATERIAL DISPOSAL HISTORY							
Site Status	Discontinued site Adjacent to NW	Discontinued site	No known disposal	No known disposal	Discontinued site NW corner	Interim Regional site	Interim Regional site
Est. Disposal (cubic yards)	—	432,000 1956-1973	—	—	13 million+ 1955-1971	5.7 million 1955-1978	7.9 million 1955-1978
Est. Capacity (million cubic yards)	33.0	21.3	44.6	74.0	91.7	42.4	21.3

Note:
In some instances, the range of data values presented here were generated from more than one source. Where site specific data are available, they are consistent with the ranges indicated herein. For information on data sources and relative data quality for the various parameters presented for each site, refer to the accompanying Table III.B-2.

TABLE III.B-1 (Continued)

SITE Selected Characteristics	A Bridgeport East	B Branford	C Six Mile Reef	D Block Island Sound	E Eatons Neck East	F New Haven	G New London
SEDIMENTS/SEDIMENT QUALITY							
Predominant Type/ Character	Silt-clayey silt/ soft	Silt-clayey silt/ soft	Fine-medium sand/ hard	Silty sand ?	Sands, silty sand, gravelly sand/ hard to soft	Silt-clayey silt/ soft	Clayey site (spoil) silty sand/soft
Silt and Clay (% dry weight)	80-85	50-90	0-5	1-10	less than 1 to 60	80-90	Approximately 70
Est. Long Term Natural Sedimentation Rate ($kg/m^2/yr$)	0.5-0.8	0.8	0	0	0.3-0.4	0.7-0.8	0
Organics (% dry weight)	0-4	2-4	0-1	NA	0-6	0-2	0-5
Trace Metal Concentrations In Near Surface Sediments (ppm)							
Cd				2.0*	0.75-1.00	0.5-1.7	0.1-1.1
Co				10.7	8.0-9.5	5.0-7.5	2.1-8.1
Cr				14.8	30-75	40-75	6-48
Cu				NA	60-90	43-81	3.8-42
Fe	NA	NA	NA	NA	$1.0\text{-}2.0 \times 10^4$	$1.1\text{-}1.2 \times 10^4$	$0.26\text{-}2 \times 10^4$
Hg				0.05	0.30-0.70	0.17-0.39	0.02-0.62
Ni				17.0	20-55	15-27	3.9-53
Pb				15.4	55-75	28-36	4-60
Zn				42.2	135-220	80-125	16-123
Volatile Solids (%)				NA	3-20	4-7.5	ND-6.8
Oil & Grease (ppm)				NA	1-6	$1\text{-}2 \times 10^3$	0.8-9.3
PHYSICAL OCEANOGRAPHY							
WAVES							
Significant Wave Height (meters)	0.8-0.9	1.2-1.3	1.2-1.3	2.7-3.1	0.6-0.7	1.2-1.3	1.2-1.4
Significant Wave Period (seconds)	3.4-3.6	4.3-4.5	4.3-4.5	7.0-9.0	3.0-3.2	4.3-4.5	4.4-4.7
Wave Induced Bottom Velocity for Specified Height/Period (cm/sec)	0	3-5	1-2	17-40	0	2-3	4-7

*The trace metal concentrations presented here for sediment at Site D - Block Island Sound were obtained at a previously investigated alternative disposal site known as East Hole. The East Hole site is located at 41°13.9'N, 71°51.0'W, approximately five kilometers west-southwest of Site D.

TABLE III.B-1 (Continued)

SITE Selected Characteristics	A Bridgeport East	B Branford	C Six Mile Reef	D Block Island Sound	E Eatons Neck East	F New Haven	G New London
<u>CURRENTS - NEAR SURFACE TIDAL</u> (Velocity and predominant direction)							
Average flood (cm/sec)	20-25 W	22-26 W	60-65 W to S	30-40 W	32-34 W to S	25-30 W	30-40 W
Average ebb (cm/sec)	17-28 E	28-29 E	65-70 E to NE	40-50 E to NE	25-30 NE	20-25 E	50-60 NE
Net drift (cm/sec)	3 W	4 E	4-5 E	4-6 E to SE	6 SW	2-3 W	4-7 E to NE
Maximum flood (cm/sec)	45-50 W	30-40 W	75-90 W to SW	60-65 W	40-55 W to SW	34-45 W	70-90 W
Maximum ebb (cm/sec)	25-45 E	45-55 E	90-110 E to NE	65 E to NE	50 NE	35-40 E	95-100 NE
Maximum average (cm/sec) (Root mean square)	25-35	28-33	60-70	45-50	33-38	25-30	60-70
<u>CURRENTS - NEAR BOTTOM TIDAL</u>							
Interpolated Maximum (cm/sec) (Velocity & direction)	20-25 W to SW	25-30 E to ENE	50-55 E	35-45 E to SE	28-33 W to SW	27-31 W	40-45 E to NE
Net drift (direction)	W to SW	E to ENE	E to NE	W	W to SW	W	E to ENE
<u>WATER COLUMN STRATIFICATION</u>							
Seasonal character (worst case) (summer)	Mild water column stratification to strong upper layer stratification	Strong mid-layer stratification	Mild water column stratification	Mild water column to strong upper layer stratification	Mild stratification	Strong mid-layer stratification	Strong upper layer stratification
Vertical density gradient $(\rho - 1) \times 10^3$ gm/cm^3/m	0.05 to 0.19	0.1 to 0.12	0.05 to 0.09	0.05 to more than 0.1	0.03 to 0.08	0.1	more than 0.1

TABLE III.B-1 (Continued)

SITE Selected Characteristics	A Bridgeport East	B Branford	C Six Mile Reef	D Block Island Sound	E Eatons Neck East	F New Haven	G New London
WATER QUALITY							
Salinity (water column range)	22-29	22-29	28-30	29-33	24-29	22-29	24-32
Suspended matter concentration (μg/liter)	1.0×10^4 to 2.0×10^4	1.0×10^4 to 2.0×10^4	1.0×10^4 to 2.0×10^4	250 to 1000	1.0×10^4 to 9.0×10^3	1.0×10^4 to 2.0×10^4	1.0×10^3 to 1.0×10^4
Near bottom dissolved oxygen (% of saturation)	35-40	65-75	more than 80	more than or equal to 80	45	55-65	more than or equal to 80
Nutrients (water column average) (μg/liter)							
Ammonia NH_3	1.0-5.0	1.0-5.0	less than 1.0	less than 1.0	1.0-5.0	1.0-5.0	less than 1.0
Nitrite NO_2	less than 0.05	more than 0.3	0.05-0.1	0.1-0.3	0.1-0.3	more than 0.05	0.1-0.3
Nitrate NO_3	1.0-5.0	less than 1.0	less than 1.0	less than 1.0	1.0-5.0	less than 1.0	1.0-5.0
Active phosphate	more than 1.0	more than 1.0	0.4-1.0	0.4-1.0	more than 1.0	more than 1.0	1.4-1.0
SITE USE VALUE CONSIDERATIONS							
Research/ Monitoring	None Known	None Known	None Known	Regionally	—	—	—
Military Use/ Testing	—	—	—	Acoustic Range	—	—	Ship/Sub Traffic Area
Cable Areas	—	—	—	—	Adjacent to East	SE Corner	—
Sport Fishing	—	—	To N on Six Mile Reef	—	Common	—	Area to W
Trawling	X	X	X	X	Area adjacent to S	—	Area to N and E
Shell Fishing	—	—	—	—	Leased oyster ground 4 km to N	—	—
Lobster Fishing	Adjacent to W	—	Adjacent to S	—	Heavy	—	Adjacent to S

TABLE III.B-2

KEY DATA SOURCES AND RELATIVE DATA QUALITY*

Site Characteristics	A Bridgeport East	B Branford	C Six Mile Reef	D Block Island Sound	E Eatons Neck East	F New Haven	G New London	Overall Data Quality
Physical Dimensions/Character	I 32	I 32	I 32	I 32	I 22, 32	I 22, 32	I 6, 22, 32	I
Dredged Material Disposal History	I 43	I 43	II 43	II 12	I 21, 43, 44	I 12, 43	I 12, 43	I
Sediments/Sediment Quality	I 3, 14, 30, 47	I 3, 14, 30, 46	II 3, 14, 30, 46	II 10, 11	I 3, 4, 14, 21, 22, 23, 38	I 3, 14, 16, 22, 30, 46	I 6, 10, 11, 14, 22, 30, 46	I
Sediment Trace Metals	V	V	V	III 10, 11	I 21, 22	I 3, 22	I 22	III
Waves	IV 20, 22, 45	IV 20, 22, 45	IV 20, 22, 45	IV 20, 22, 45	IV 20, 22, 45	IV 20, 22, 45	IV 20, 22, 45	VI
Currents	III 18, 19, 33, 37, 38	III 16, 17, 18, 19, 33, 37, 38	III 9, 13, 17, 18, 19, 33, 37, 38, 41	III 33, 37, 38	I 18, 19, 22, 31, 37, 38	I 16, 17, 18, 19, 22, 33 37, 38	I 9, 13, 18, 19 22, 33, 37, 38	II
Water Column Stratification	III 18, 19	III 17, 18, 19	III 17, 18, 19	IV	III 18, 19	III 17, 18, 19	III 18, 19	III
Water Quality	I 1, 5, 18, 19, 24, 27, 30, 42	I 1, 5, 16, 18, 19, 24, 27 30, 42	III 1, 5, 18, 19, 24, 27, 30, 42	III 2, 10, 11, 29, 36	I 1, 4, 5, 18, 19, 21, 27, 30	I 1, 5, 16, 18, 19, 24, 27, 30, 42	I 2, 5, 6, 9, 10, 11, 18, 19, 24, 27, 30, 42	II
Site Use Value Considerations	I 7, 8, 15, 25, 26, 27, 32 43, 48	I 7, 8, 22, 25, 26, 27, 32, 43, 48	II 7, 8, 12, 22, 25, 26, 27, 32, 43, 44, 48	III 11, 12, 22, 32, 34, 43, 44	I 7, 8, 22, 25, 26, 27, 32, 43, 44, 48	I 7, 8, 16, 22, 25, 26, 27, 32, 35, 43, 44, 48	I 6, 7, 8, 10, 11, 12, 22, 25, 26, 27, 31, 32, 43, 44, 48	I
Overall Relative Site Specific Data Quality	II	II	III	III	I	I	I	II

*Notes:
Key Data Sources for each site specific characteristic are indicated by a number referring to a reference listed below. Complete citations can be found in the Reference section.
Relative Data Quality is rated here using a roman numeral designation representing one of the following:

- I Excellent data quality - site specific data available
- II Good data quality - little site specific data but local data available
- III Fair data quality - no site specific or local data-characteristics extrapolated from regional data sources/information
- IV Poor data quality - information derived indirectly from various data or information sources
- V *No Data or extrapolation impractical*

Table III.B-2 (Continued)

Key Data Sources

1. Anderson and Muller, 1978
2. Bohlen, 1974
3. Bokunewicz et al., 1976
4. Bokunewicz, 1977
5. Bouman, 1979
6. Brown, 1978
7. Carlisle and Wallace, 1978
8. Connecticut DEP, 1977
9. Dehlinger et al., 1976
10. Department of the Navy, 1974
11. Department of the Navy, 1976
12. Department of the Navy, 1979
13. Dehlinger et al., 1976
14. Feldhauser et al., 1976
15. Freeman and Walford, 1974
16. Gordon et al., 1972
17. Gordon and Pilhean, 1975
18. Hardy, 1970
19. Hardy, 1971
20. Lettau et al., 1976
21. Marine Science Res. Center, 1978
22. Naval Undersea Systems Center (NUSC) and U.S. ACOE, 1978
23. NUSC and U.S. ACOE, May 1979
24. New England River Basin Commission (NERBC), 1973
25. NERBC, January 1975
26. NERBC, February 1975
27. NERBC, March 1975
28. NERBC, 1979
29. New York Ocean Sciences Lab.
30. NOAA & NMFS, 1974
31. NOAA - NMFS, 1977
32. NOAA-NDS Nautical Chart 1977, 1978, 1979
33. NOAA - NDS, 1977
34. Olsen and Stevenson, 1975
35. Rhoads et al., 1972, 1973, 1974
36. Rhode Island Statewide Planning Program, 1978
37. Riley, 1952
38. Riley, 1959
39. Serafy et al., 1977
40. State University of New York, 1978
41. Swanson, 1971
42. Turekian, 1971
43. USACOE, January 1979
44. USACOE, January 1979
45. U.S. Army - CERC, 1977
46. U.S. Naval Weather Service Command, 1970
47. Williams (unpublished)
48. Wise, 1975

frustrum are assumed to be at a 1:10 slope which is comparable to slopes measured in field observations. A minimum water column depth of 15 meters is used to provide draft clearance for deep draft vessels traversing these waters. Greater depth clearances are provided at some sites based on Coast Guard recommendations (Harrald, 1980). An evaluation of the variation of wave induced bottom currents as a possible limitation on the upper depth of the mounds at each site indicated that waves associated with a surface wind of 20 knots (10.3 cm/sec) are insignificant as compared to the near-bottom tidal strength.

III.B.1 Site A - Bridgeport East

III.B.1.a Physical Characteristics

Site A is three kilometers east of the discontinued Bridgeport dredged material disposal site located in the central Long Island Sound approximately, 5 kilometers south of the Bridgeport/Pequonnock River Entrance Channel. The Bridgeport disposal site received almost 4 million cubic yards of dredged material between 1954 and 1977.

The suitable site area, depicted on Figure III.B-1, trends northwest-southeast and lies in water depths ranging from 16 to 24 meters. The bottom in the vicinity of the site slopes very gently and smoothly to the south. A shallow rocky area, known as Stratford Shoal Middle Ground, lies about 5 kilometers to the east. The site is along the main approach for larger vessels to Bridgeport Harbor. The 15 meter draft clearance provided in computing the site capacity is adequate for this area (Silberman, 1980).

The sediments at Site A are silts and clayey silts with less than 20 percent sand fraction and the area appears to be one of natural sediment accumulation. Bottom tidal currents indicate, in the range of 20-25 cm/sec.

The site was selected within the area of highest local environmental suitability. The location southeast of the discontinued Bridgeport disposal site separates the selected site from the lobster fishery around the Old Bridgeport site. The water depth range of 21 to 25 meters also provides for greater site capacity than would be found in the surrounding shallower local areas.

Besides the fisheries resources discussed below, and the ferry route which passes to the east of Site A, there is no other known significant conflicting use value for the site or areas immediately adjacent to it.

No site specific research or monitoring programs have been undertaken at the discontinued Bridgeport dumping site so few data are available regarding the specific effects of disposal there. A majority of the physical and chemical parameters presented for Site A in Table III.B-1 have been extrapolated from data sources outside the site area.

III.B.1.b Benthic Fauna

Due to the muddy sediments and proximity to the old disposal site, most of the site is probably characterized by low species diversity (Figure III.B.2). The benthic fauna occurring here probably are typical of those types which occur within the fine deep water sediments described in MAFC, 1974 (see also Section III.A.3.c). It is primarily a polychaete-bivalve assemblage. "Cosmopolitan" species are those which

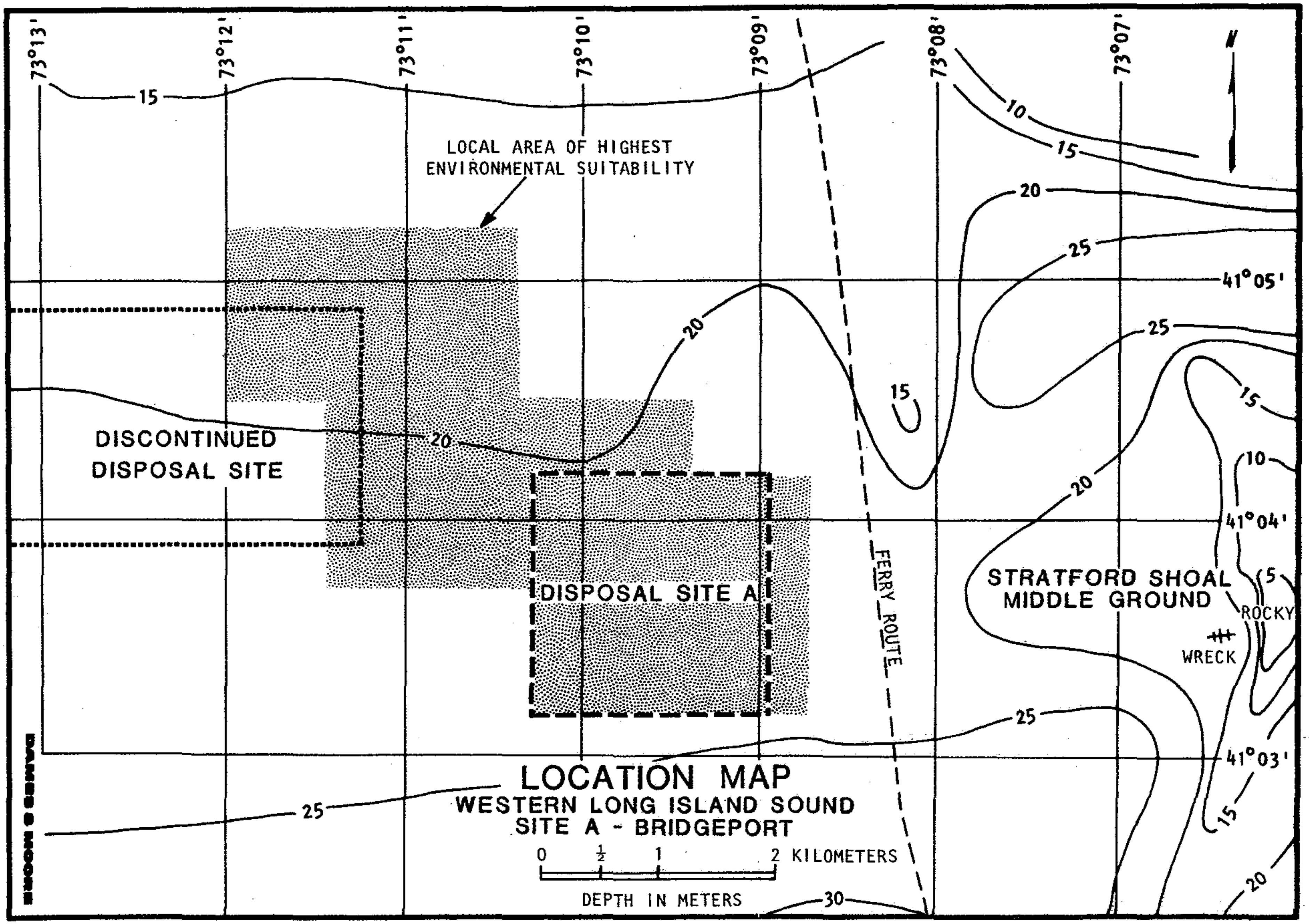
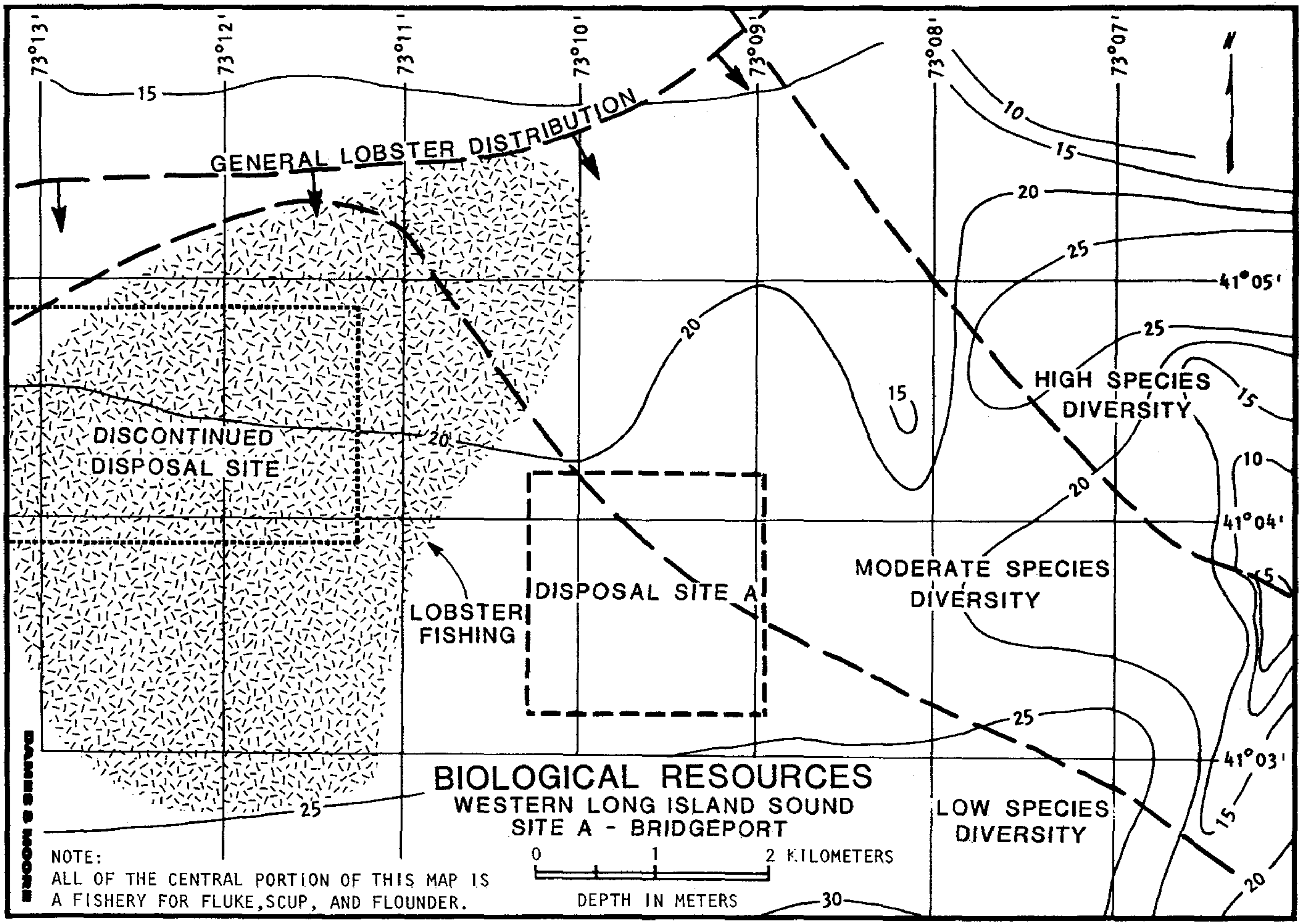


FIGURE III.B-1



BIOLOGICAL RESOURCES
WESTERN LONG ISLAND SOUND
SITE A - BRIDGEPORT

FIGURE III.8-2

find various habitats (i.e., temperature ranges, water quality requirements and bottom types) suitable for colonization. Their abundance, although not necessarily dominant, may be significant in different communities. Such typical "cosmopolitan" fauna occurring in many areas on different habitats within the Sound would probably be found here, including several polychaetes, gastropods, and crustaceans. A bivalve was very abundant with about 1400 individuals collected in a single 0.1 m^2 grab (MAFC, 1974). Species diversity was low at this station. However, this was probably related to the large number of bivalves collected. The benthic species found at and near this candidate site can be found in MAFC (1974) and NOAA (1976).

III.B.1.c Fisheries

The area around and including Site A is utilized by commercial fisherman for scup, flounder and fluke (USACOE, January, 1979). About 25 percent of the menhaden landings occur in the western Long Island Sound region (Connecticut DEP, 1979). A lobster fishing area can also be found about 0.5 km to the west of the site (Figure III.B-2). Nearly 42 percent of the lobster landings of all the Sound are taken in western Long Island Sound (Connecticut DEP, 1979). Recreational fishing probably occurs around the Stratford Shoal Middle Ground about 6 km to the east. Species such as bluefish, blackfish and sea robins are popular catch with the sportfishermen.

III.B.2 Site B - Branford Dredged Material Disposal Site

III.B.2.a Physical Characteristics

Site B is in the area of highest environmental suitability for dredged material disposal within Long Island Sound, and is centered about 12 kilometers south of Branford, Connecticut and 10 kilometers southeast of the New Haven Harbor entrance Channel in the central basin area of Long Island Sound. The dredged material disposal site is situated at the location of the discontinued Branford disposal site (see Figure III.B-3) to minimize the impacts of dredged material disposal in previously undisturbed areas of the Sound.

Between 1956 and 1973, the Branford site received about 432,000 cubic yards of dredged material, predominantly from the Branford Harbor/River Channel. Little specific information is available on the effects of the disposal on the historical Branford site. Some baseline physical, chemical, and biological observations are available in the site vicinity (Gordon et al., 1972; Middle Atlantic Coastal Fisheries Center, 1974).

Water depths in the Branford disposal site range from about 18 to 23 meters and the natural bottom slopes gently and smoothly to the southeast. The site is in the vicinity of an unmarked anchorage area for large vesels. A draft clearance of 18 meters is required here (Silberman, 1980).

The site area is one of natural sediment accumulation. The bottom is covered predominantly with silts and clayey silts with sand size particles accounting for between 10 and 50 percent by weight.

Maximum bottom tidal currents are predominantly shore-parallel (east-west) and fall within the range 25-30 cm/sec. Estimated wave-induced bottom water velocities are similar to those for the other Long Island alternative sites (Table III.B-1).

Other than general lobster distribution in the area, no specific use value conflicts have been identified for the Site B area.

III.B.2.b Benthic Fauna

The habitat and benthic fauna at Site B are probably typical of other interim/old disposal sites in Long Island Sound. The benthic fauna are characterized by opportunistic species--those which play a role in the early succession in areas which have been disturbed. These species typically colonize and dominate disturbed areas, have short life spans, and are capable of rapid reproduction cycles. However, other species usually become dominant over time unless the disturbance is continuous or repeated at frequent intervals. The typical "cosmopolitan" species found throughout the Sound would also be present.

One station from the MAFC (1974) study lies within the Site B area. Four species of molluscs were numerically dominant. Other abundant organisms include polychaetes and amphipod. This site lies mostly within a zone of moderate diversity with a band of low diversity occurring along the southern border (Figure III.B-4). It

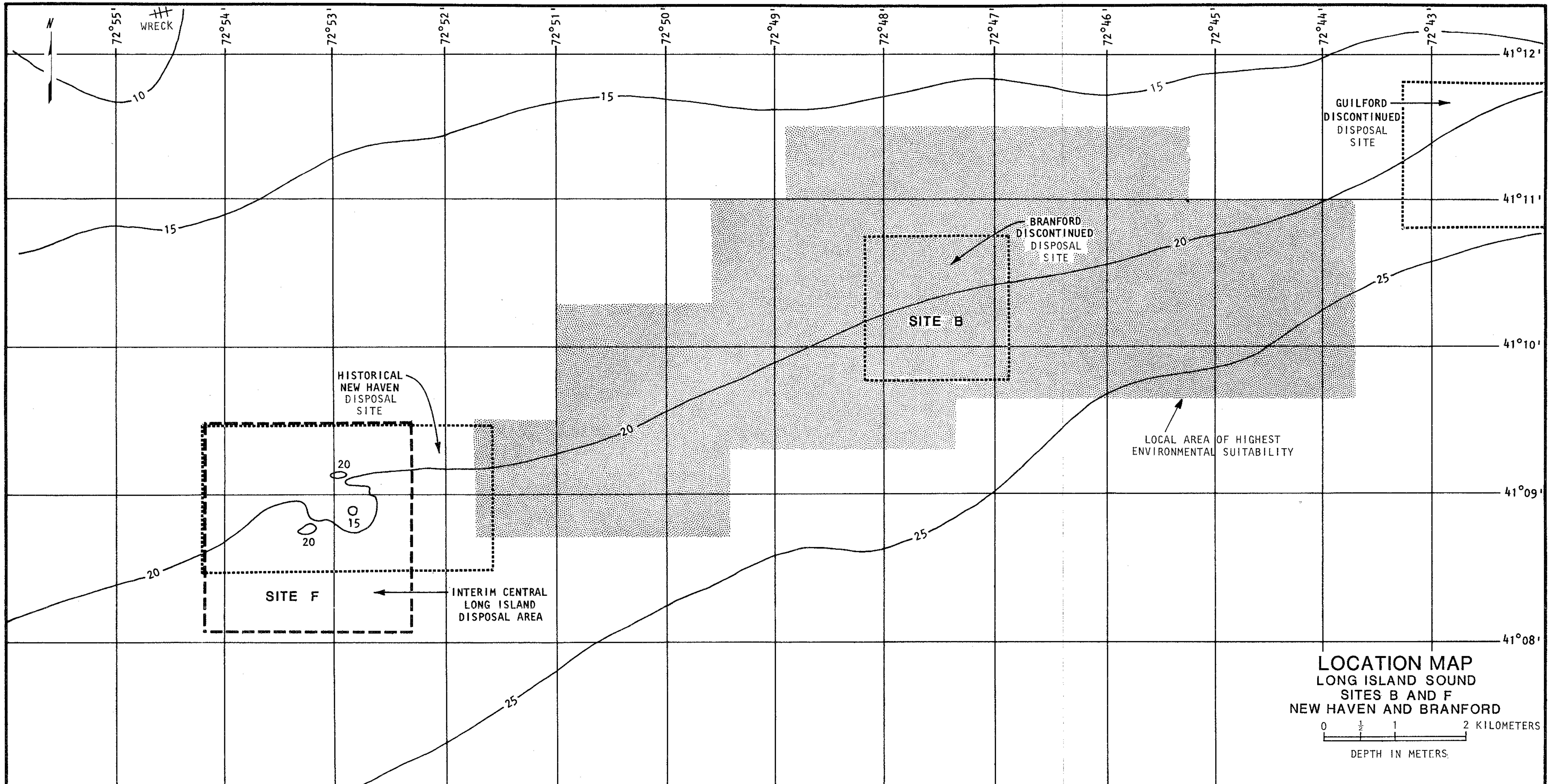


FIGURE III.B-3

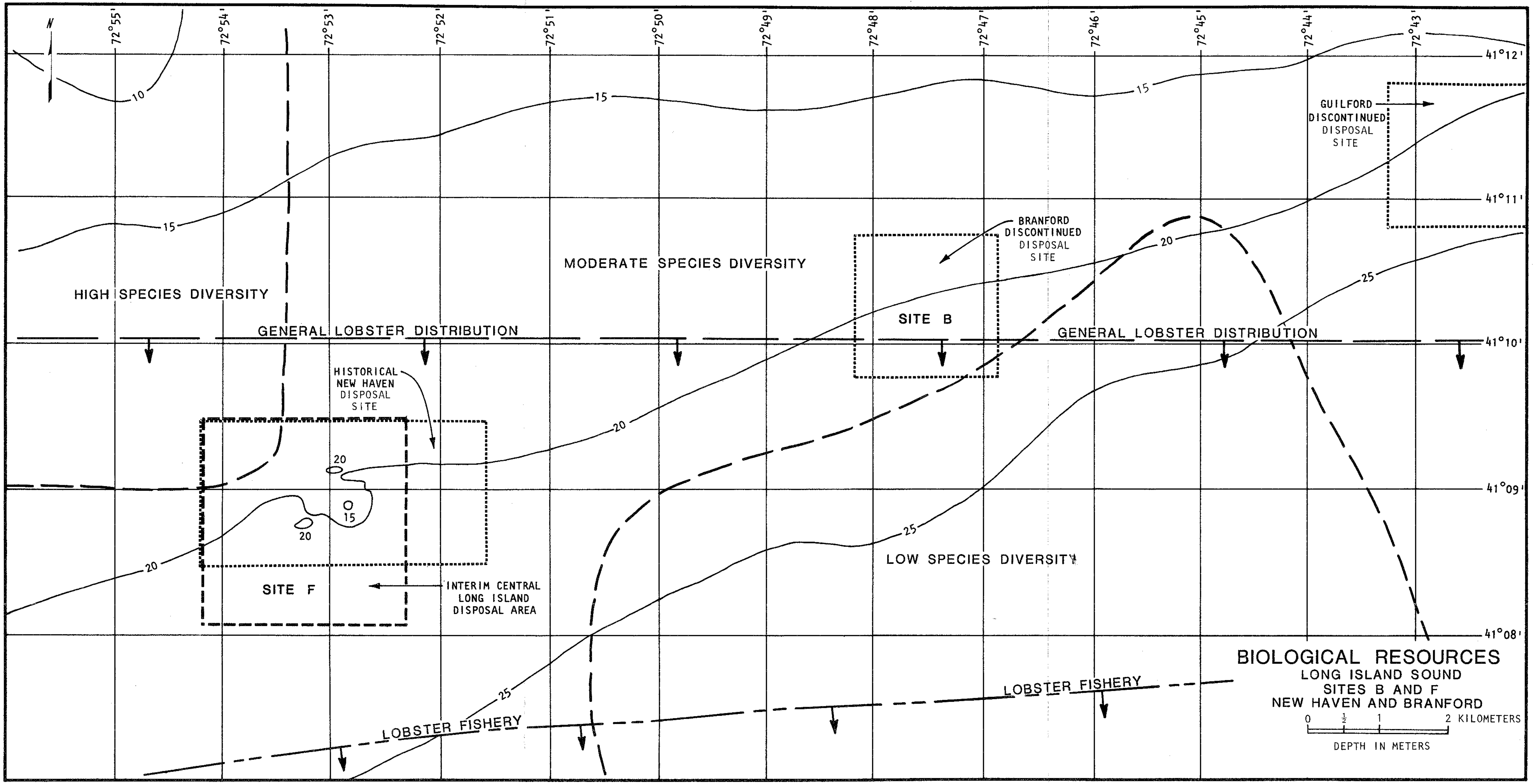


FIGURE III.B-4

also falls within the general distribution zone for lobster. However the lobster fishing zone is about 4 km to the south (Figure III.B-4).

III.B.2.c Fisheries

Fishing in the area is rather light and no commercial activity was mapped nearby (USACOE, January, 1979). Most of the finfishing activity in the region is probably recreational for bluefish, blackfish and sharks centered around shoals and banks.

III.B.3 Site C - Six Mile Reef

III.B.3.a Physical Characteristics

Site C is approximately 18 kilometers southwest of the entrance of the Connecticut River and 15 kilometers south of Clinton, Connecticut. The site is an east-west elongated area situated in 15 to 33 meters of water between Six Mile Reef on the north and a shallow rocky area to the south-southwest (Figure III.B-5). Six Mile Reef is part of the Mattituck Sill, a submarine ridge which divides the Long Island Sound into the Central and Eastern basins.

The dredged material disposal site is in the western portion of the local area of highest environmental suitability. The water depth of the site ranges from 25 to 33 meters. Just north of Site C the bottom rises steeply to within 7 meters of the surface on Six Mile Reef. The bottom slopes upward more gradually to the south and is almost flat to the east.

The site is near the main shipping lane for Long Island Sound. Vessels with drafts of up to 20 meters cross this area. A draft clearance of 21 meters should be maintained at the site (Silberman, 1980).

A smaller suitable sub-area in the vicinity of Site C extends into the southwest-northeast trending depression which lies 4 kilometers south of Six Mile Reef (Figure III.B-5). Water depths in that depression reach 49 meters. This sub-area was ruled out as the preferred dump site, despite obvious depth/capacity advantages, due to the lobster fishing grounds there (Figure III.B-6).

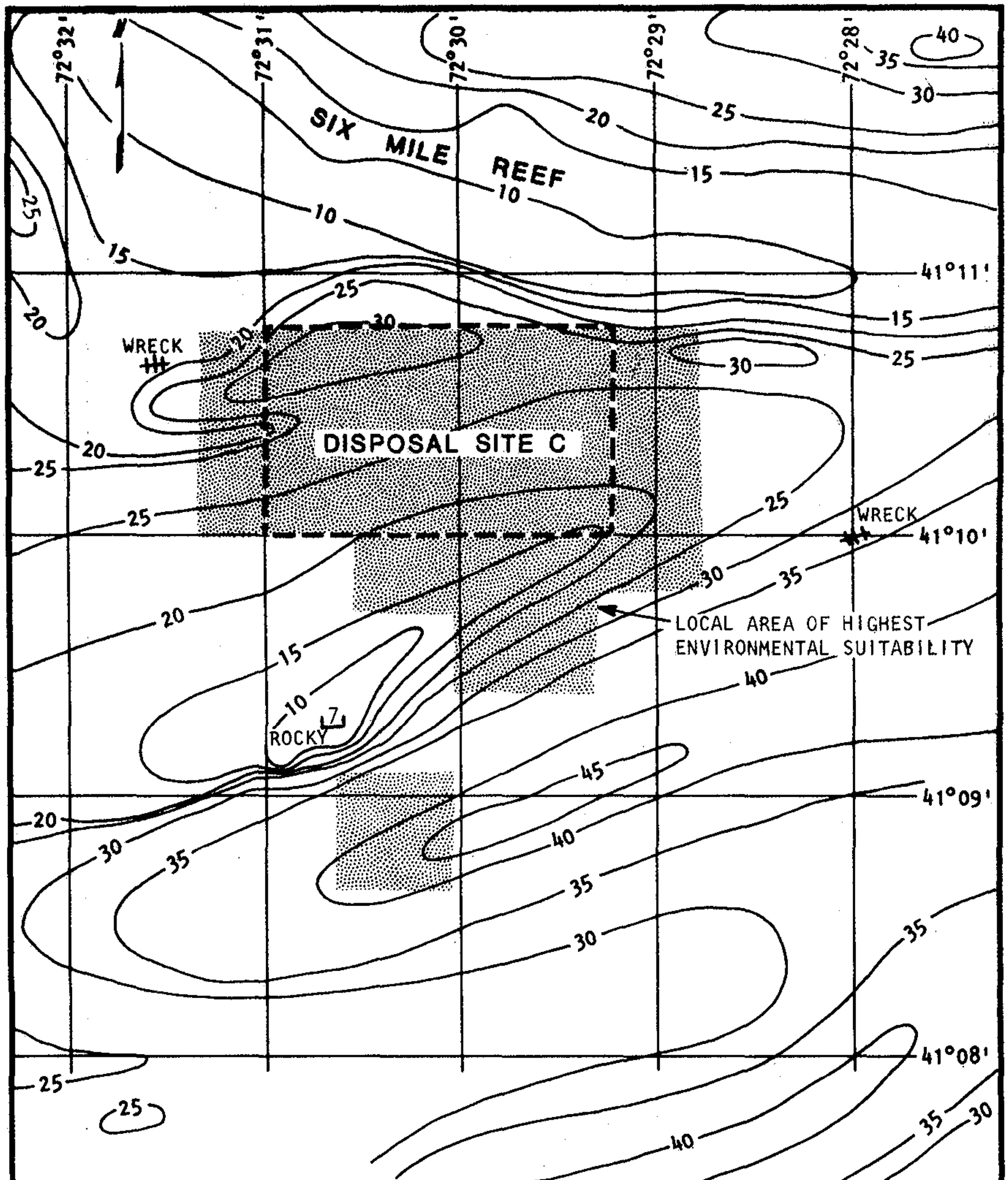
The sediments in the vicinity of Site C are fine to medium sands with less than 5 percent silt and clay fraction. The site is in an area of the Sound where there is no evidence of long term natural sedimentation.

Peak and average tidal current velocities at Site C are higher than for all other alternative sites except the historical New London site. Maximum bottom tidal currents are high, ranging from 50-55 cm/sec. The estimated wave induced bottom velocities at Site C are low and comparable with other western Long Island Sound alternative sites.

Site C has no known history of disposal; there is no known research or monitoring taking place in the immediate vicinity of the site. There is no significant local conflicting use value, other than lobster fishing, that might be affected or precluded by the disposal of dredged materials.

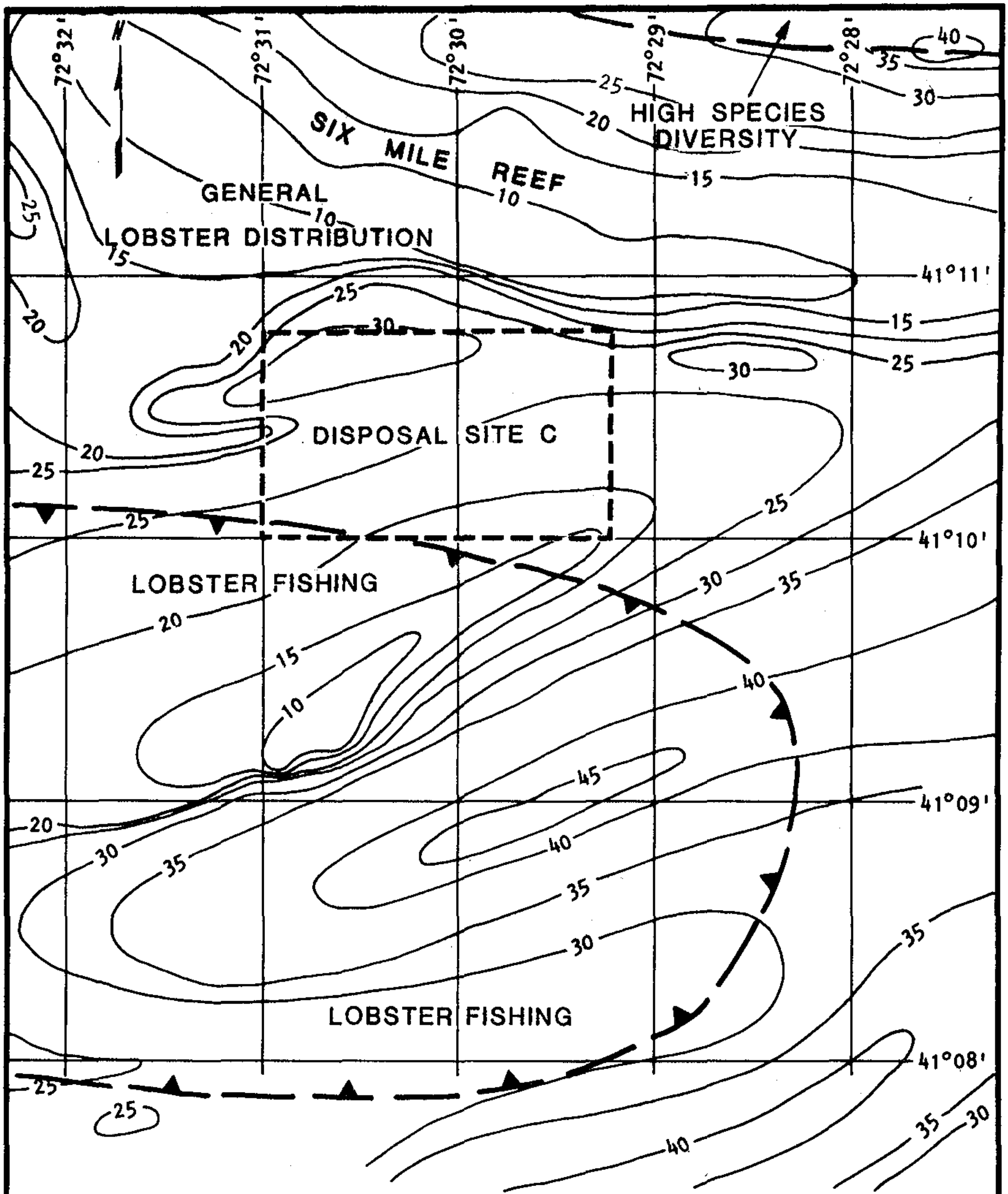
III.B.3.b Benthic Fauna

No site data existed for Site C in central Long Island Sound. However, two stations from a 1973 MAFC survey are within one mile north and south of the site. The benthic fauna were very sparse on a fine sand bottom very low in organic matter. That only twelve species were reported between the two stations is probably due to the lack of organic material. Amphipods dominated the fauna. Overall the area lies within a zone of moderate diversity (Figure III.B-6). Only one species of bivalve was taken along with four species of polychaetes.



LOCATION MAP
LONG ISLAND SOUND
SITE C - SIX MILE REEF

FIGURE III.B-5



BIOLOGICAL RESOURCES

LONG ISLAND SOUND

SITE C - SIX MILE REEF

0 ½ 1 2 KILOMETERS

NOTE:
ALL AREAS ARE OF MODERATE DIVERSITY EXCEPT AS INDICATED.

DEPTH IN METERS

DAMES & MOORE

FIGURE III.B-6

III.B.3.c Fisheries

Site C lies within a zone of central Long Island Sound identified as general distribution for the lobster (Figure III.B-6). NUSC (1978) data indicate that lobstering is not very active in the region around the Cornfield Shoals dump site, which is about 16 km northeast of Site C. However, they did report a fair distribution of lobster around the rubble mounds at that disposal site. USACOE, NED (January 1979) report lobster fishing to the south of Site C.

Blue mussels may be found in harder areas around Six Mile Reef and the Middle Ground north and east of Site C. Other shellfish are limited to habitats nearer to shore. These areas are also popular with sportfishermen for tautog, flounder, blackfish, and bluefish. Commercial fishing activity is apparently not intense at this site. Major commercial activity occurs to the west and north of this site.

III.B.4 Site D — Block Island Sound

III.B.4.a Physical Characteristics

Currently, Block Island Sound has no active dredged material disposal sites. Site D, the area of highest suitability for disposal in Block Island Sound, is centered about 18 kilometers northwest of Block Island, twelve kilometers east of Fishers Island, and nine kilometers southeast of Watch Hill Point, Rhode Island (see Figure III.B-7). That location is on the northwestern portion of a large submarine plain that underlies much of central Block Island Sound. A steep-sided depression lies approximately two kilometers southwest of Site D. Water depths within two kilometers of the center of the surface range from 30 to 34 meters.

Site D is located approximately 2 kilometers south of the major shipping lane between Narragansett Bay and Long Island Sound. Concerns for safe navigation have been expressed (Sutherland, 1980).

Bottom sediments in the vicinity of Site D are silty sands with less than 10 percent silt and clay content.

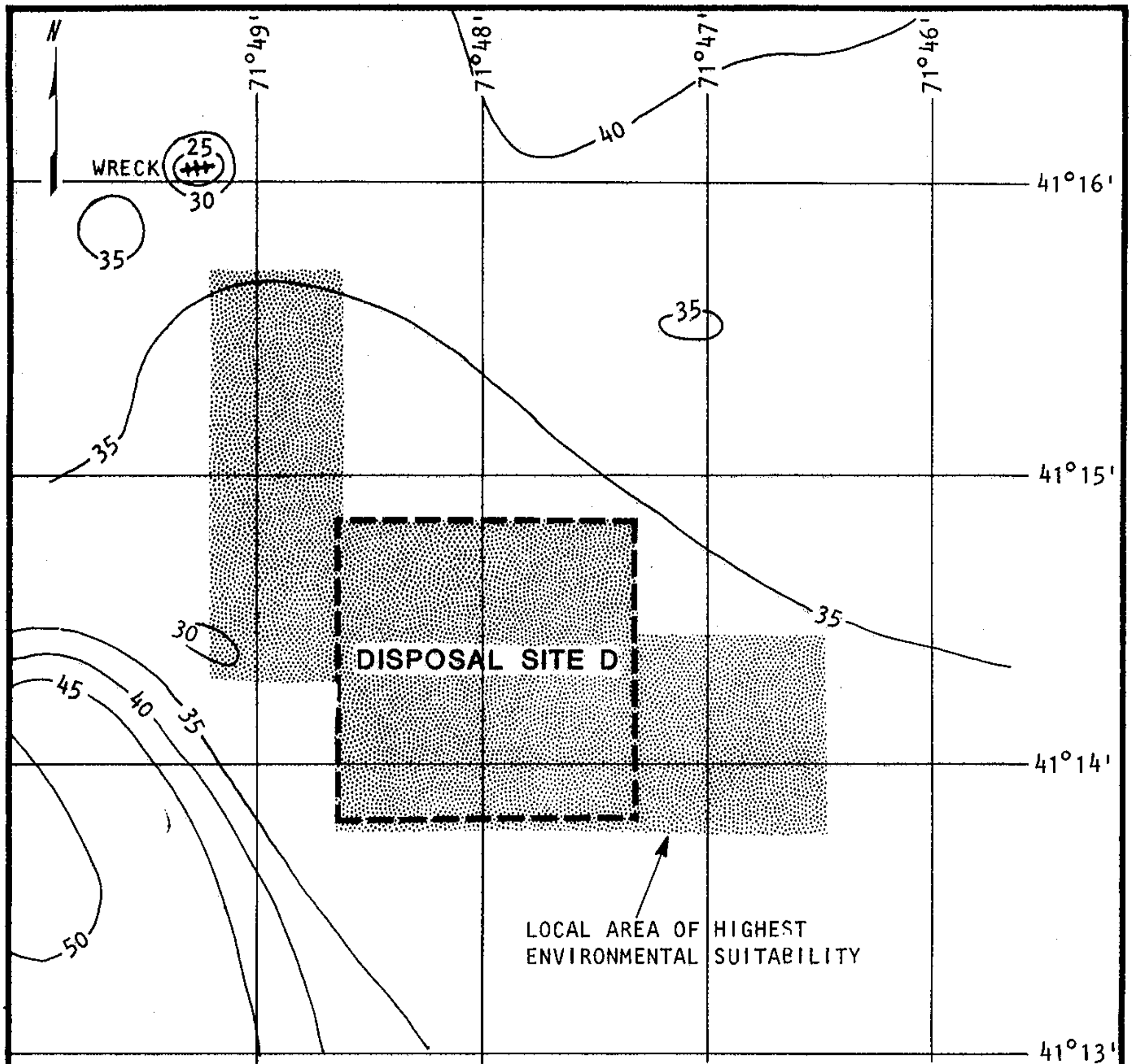
Of the seven candidate sites considered in detail in this report, the Block Island Site has the highest significant wave induced bottom water velocities (17-40 cm/sec; Table III.B-1). Average and peak tidal current velocities, on the other hand, are comparable to those for most of the sites in the Long Island Sound.

The central Block Island Sound is generally considered to be an area of recreational boating and heavy commercial fishing. The Sound is also used by military, marine regulatory, and university groups for testing, environmental research and monitoring programs. More specifically, the area between Block Island and Fishers Island is periodically used by the Naval Underwater Systems Center as an acoustic range (BIFI Range). Research, testing, and monitoring groups include the University of Rhode Island, University of Connecticut, Yale University, New York Ocean Science Lab, NOAA, and National Marine Fisheries Service also utilize this area of Rhode Island Sound. However, no specific use of Site D is known and it is unlikely that those programs would be significantly affected or precluded as a result of dredged material disposal there.

III.B.4.b Benthic Fauna

No site specific data exist for the benthic fauna of Site D and there are no data from stations very near the site. Extrapolated sediment data indicate the site lies in an area of silty sand and sand. The sand to mud ratio noted above would probably be favorable for a relatively diverse benthic community VIMS (1977).

Sampling in the Block Channel area (dispersal disposal site #2) also indicated a silty sand to sand bottom without gravel, stones or rocks (Navy, 1974). Bottom fauna were generally burrowing organisms. Polychaetes and amphipods were abundant. The jacknife clam was observed along with the sand dollar and rock crab (Navy, 1974). Other "cosmopolitan" fauna would probably also occur in the area.



LOCATION / BIOLOGICAL RESOURCES MAP

BLOCK ISLAND SOUND

SITE D

0 ½ 1 2 KILOMETERS

DEPTH IN METERS

NOTES:

1) ENTIRE AREA INCLUDED WITHIN A HEAVY COMMERCIAL FISHING ZONE (DEPARTMENT OF THE NAVY, 1974).
2) NO DIVERSITY DATA AVAILABLE.
3) NO SHELLFISHING DATA AVAILABLE.
4) LOBSTERING OFF THE MAP TO THE WEST.

DAMES & MOORE

FIGURE III.B-7

III.B.4.c Fisheries

Most of the study area around Site D is trawled at some time, however the zone in which Site D is located is reported as heavily trawled (Navy, 1973) and moderately trawled (Navy, 1976). Recreational fishing spots are further west, with the exception of a near shore zone on the western coast of Block Island that extends near the southeastern edge of Site D. Intensity of fishing depends on the seasonal distribution of the locally important fishes. Olsen and Stevenson (1975) identify the following species as the principal desirable fish taken in Block Island and Rhode Island Sounds: winter flounder, yellowtail flounder, fluke, scup, butterfish, cod, haddock, whiting, and hake; and non-commercial species such as sculpins, sea robins, goosefish, ocean pout and rays.

Site D is mapped as a lightly fished area for shellfish (Navy, 1976). Principal shellfish in this area are ocean quahogs. Lobstering in eastern Block Island Sound is concentrated nearer shore around Fishers Island and the Race. Migration of lobsters is thought to occur from the area of Block Channel north and westward (Navy, 1973).

III.B.5 Site E - Eatons Neck East

III.B.5.a Physical Characteristics

Disposal Site E is located in the vicinity of the discontinued Eatons Neck dumping ground in western Long Island Sound. The area of highest local suitability trends north-south across a deep, west to east-northeast trending depression and encumbers the southeastern portion of the old Eatons Neck disposal site (Figure III.B-8). The dredged material disposal site is centered about 5.5 km north-northeast of Eatons Neck, Long Island, and 6 km south of Sheffield Island, Connecticut on the axis of the topographic depression. To the north and east of the site are steep seafloor slopes rising to shallow areas that define the geomorphic boundary between the western and central basins of the Long Island Sound.

Water depths within two kilometers of the center of the disposal site range from 15 to 58 meters. Relatively high vessel traffic is reported in this area, and the suggested draft clearance for this area is 29 meters (Silberman, 1980). This value was used in the computation of the site capacity.

Sediments at the site are generally silty sands with varying amounts of clay and gravels. The silt-clay content increases in the west-northwest direction, toward the old disposal area. Tidal currents and net drift trend roughly shore parallel along the axis of the seafloor depression. Specific current data as well as selected physical and chemical characteristics of the water column and sediments at the disposal site are presented in Table III.B-1.

Site area use/value considerations are also presented in Table III.B-1. Historically the now-discontinued Eatons Neck disposal site received dredged materials (largely silty clay) from harbors in the western Long Island Sound area. Since the beginning of the 20th century, material disposal has included construction and demolition wastes and old barges. More than 13 million cubic meters of dredge material are known to have been deposited during the period 1955 to 1971.

III.B.5.b Benthic Fauna

Site E is between the Eatons Neck site, the old western Long Island Sound disposal site, and Cable and Anchor Reef. The different sediment types have distinct benthic communities associated with each. The sand or hard area at Cable and Anchor Reef contained species of polychaetes, oligochaetes, nematodes, bivalves and amphipods (Serafy et al., 1977).

Organisms found numerically dominant in the mud zone were polychaetes, amphipods and bivalves. MAFC (1974) reported that although western Long Island Sound contains the highest concentrations of pollutants in Long Island Sound, the benthos appears stable and they suggest this region to be relatively ecologically stable. NUSC (1978) found a comparatively low number of individuals sampled relative to other sites but that values for diversity and equitability were similar for all stations. Values for benthic species diversities can be found in MAFC (1974) and NUSC (1978), although they differ somewhat it is probably due to the difference in sampling and data analysis techniques.

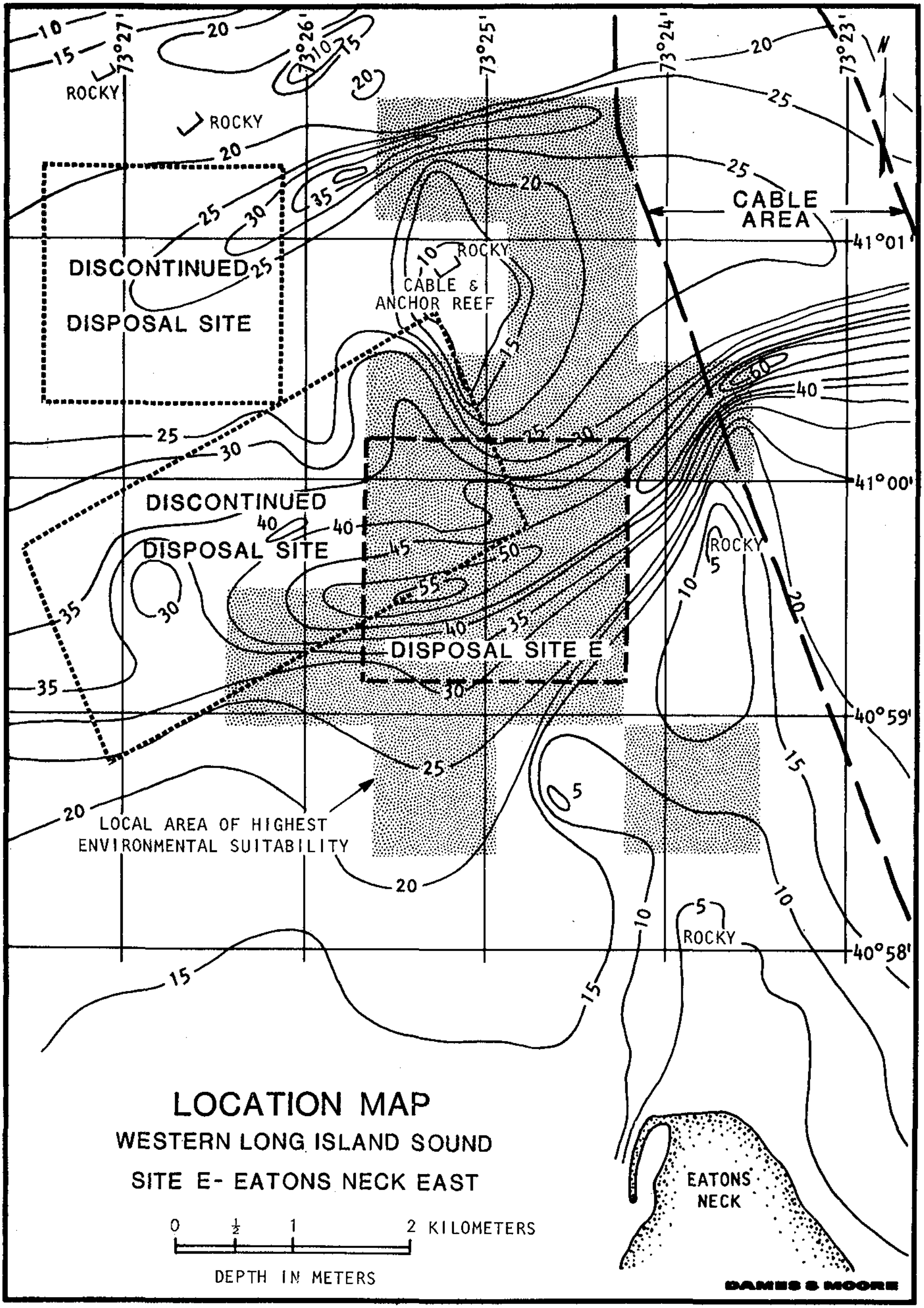


FIGURE III.B-8

Deposit feeders were most abundant in both the sand and mud zones and suspension feeders were dominant in the mud from December to June. A bivalve was dominant in the mud whereas a gastropod was most abundant in the sand (Serafy et al., 1977). Other important organisms were grass shrimp and hermit crabs.

III.B.5.c Fisheries

Lobstering is the major fishery in the area. Other types are shown on Figure III.B-9. In this area of Long Island Sound, almost all the bottom with 20 m or greater water depth is used by lobstermen (NUSC, 1978). About 42 percent of the lobsters caught in Long Island Sound come from a relatively small area of western Connecticut. A New York area adjacent to this region yielded 3.6 percent.

Pots are heavily used at Budd Reef, Eaton's Neck, and Cable and Anchor Reef, and along the 20-meter contour line east of deep channel. Pots are used heavily in summer and less in winter.

Site E is in deeper water than the hard bottomed areas off Connecticut used for oyster mariculture. Active leases occur in areas 2.5 km north of Site E with depths of 12 to 15 meters. There was a very successful oyster set in that area in 1978 (NUSC, 1978). The ocean quahog may occur here; however, due to the depth and nearly rocky bottom, there is little chance that the area would be of commercial significance.

The finfish in this area are dominated by three species of a total of 37 reported (Cobb et al., 1978). Windowpane and winter flounder are most abundant in April and January, respectively, but occur all year round. Red hake is most abundant in June, especially east of the site.

Any commercial trawling for finfish is restricted by the density of lobster pots in the area. Trawling takes place in New York south of 41° latitude and about 11 km east of Cable and Anchor Reef. There is also a tow path about 8 km west of Eatons Neck. In fall, the scup fishery is most intense, and this bottom fishery also takes lobsters.

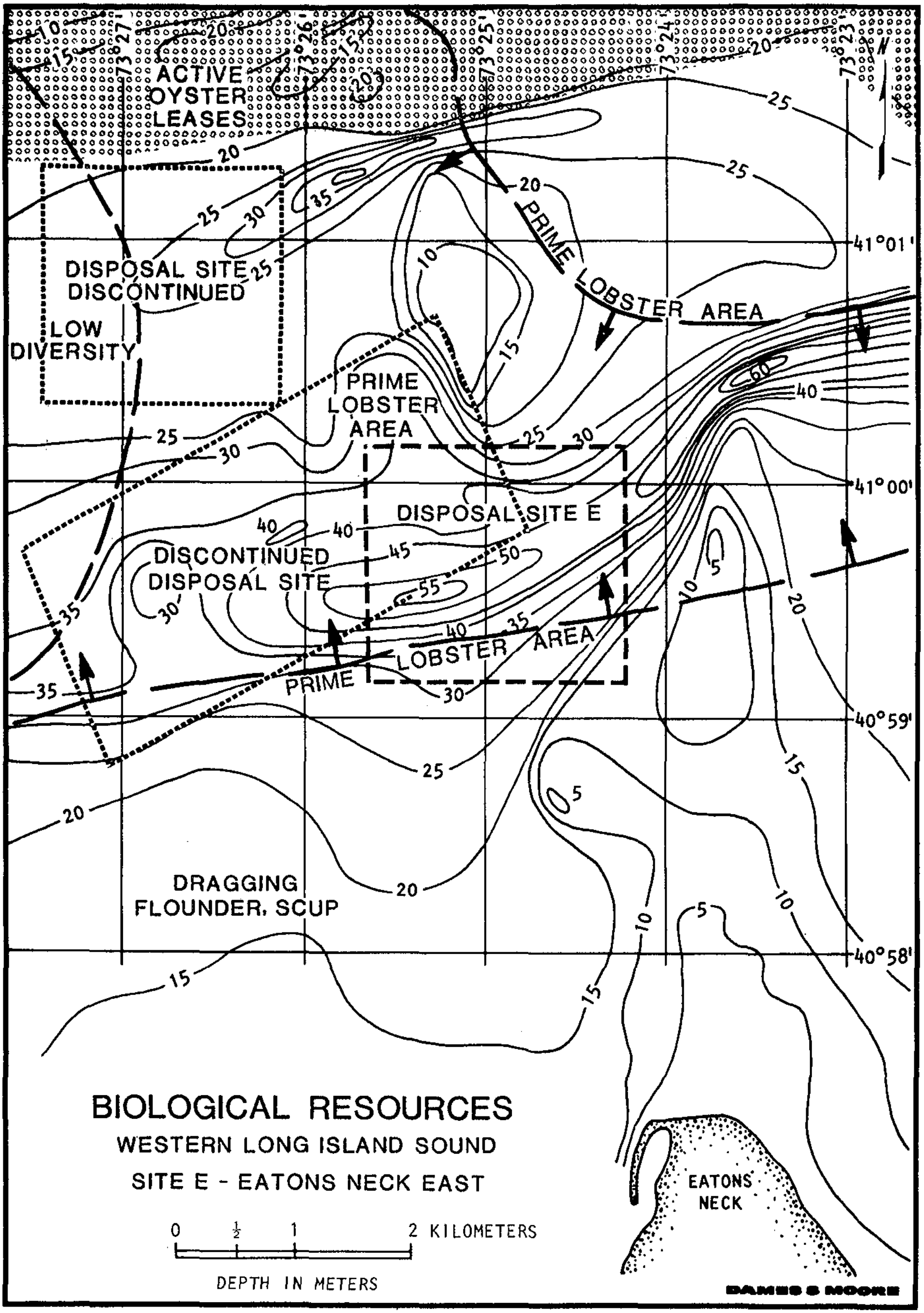


FIGURE III.B-9

III.B.6 Site F - New Haven-Central Long Island Sound Regional Disposal Area

III.B.6.a Physical Characteristics

Site F is the interim Central Long Island Sound Regional Disposal Area, located in the vicinity of the historical New Haven disposal site. The interim site is two square nautical miles in area and is situated in the central basin of the Long Island Sound, 8 kilometers south of the New Haven Harbor entrance channel. Since 1955 more than 4 million cubic meters of dredged material have been deposited there.

Water depths within Site F range from 15 to 23 meters (Figure III.B-3). Recent site bathymetric surveys by Naval Undersea System Center (NUSC, 1978) indicated a conical dredged material mound in the north central portion of the site with a minimum depth of 15 to 15.5 meters. Additional smaller spoil mounds have also been documented southwest of the main pile. The natural bottom in the vicinity of the New Haven Site slopes gently and smoothly to the south.

Site F is in the vicinity of an unmarked anchorage for large vessels. Caution is advised during dumping operations, and communication channels should be kept open at all times. The 15 meter draft clearance is adequate at this site (Silberman, 1980).

Site area bottom sediments are silts and clayey silts with less than 20 percent sand sized particles and is in an area of natural sediment accumulation. Maximum bottom tidal currents are moderate (27-31 cm/sec) and wave induced currents are low.

In addition to detailed site bathymetric studies, baseline and post dredging investigations including current measurements, sediment and water analyses, photo and scuba diver investigations, benthic and biochemical studies have also been performed (Gordon et al., 1972; NUSC, 1978). The sediment analysis showed that the relatively high concentration of heavy metal content in and around the historical dredged material disposal site compared with values measured elsewhere in the western Long Island Sound. Enrichment relative to iron at the disposal site was not as great as found in the rest of the western Sound.

III.B.6.b Benthic Fauna

Like the New London dredged material disposal site in Long Island Sound, the New Haven site has been monitored and studied more than other areas of the Sound. The disposal mounds at the New Haven site are in an early stage of recolonization in which opportunistic species rapidly reproduce and colonize. The overall sediment composition is mud resulting from dredged materials disposal. The site had moderate to high densities of amphipods and infaunal and epifaunal communities that are relatively unstable compared to other areas. MAFC (1974) sampled two stations located within the disposal site. Results of grab samples indicate that bivalves were numerically dominant.

Both stations were classed as having moderate species diversity (Figure III.B-4). More recent data taken in the DAMOS project (NUSC, 1978) indicated similar species diversities for the disposal site and reference site (NUSC, 1978). Surveys found the same polychaete to be numerically dominant at the disposal site and reference site. Although diversity remained quite similar, dominant organisms changed drastically. Two bivalves were also taken in the DAMOS samples and each had less than 3 individuals. Photo studies of bottom sediments at the disposal site indicate evidence of benthic activity. Densities of polychaete tubes are probably helpful in stabilizing the bottom. Starfish, anemones, bivalves and gastropods were all observed at the disposal site (Gordon et al., 1972).

III.B.6.c Fisheries

The New Haven site falls within the general lobster distribution zone in central Long Island Sound (Connecticut DEP, 1978) (Figure III.B-4). About 1.5 km to the south of the site is an area utilized by the lobster fishery. This central region of Long Island Sound accounts for less than 20 percent of the lobster fishery of the Sound (Connecticut DEP, 1979). Commercial fishing is limited and concentrated in areas to the west and east where fluke, scup, flounder and menhaden are taken. Recreational fishing is also light at Site F. Most of the activity for bluefish, blackfish and sharks occurs at the shoals and shallower features generally removed to the west, north and east of the site.

III.B.7 Site G - New London Disposal Area

III.B.7.a Physical Characteristics

The New London disposal site is an active interim dredged material disposal site located in the northeast corner of the eastern basin of Long Island Sound. The center of the site is situated about 3 km south of the entrance to the New London Harbor entrance channel (Thames River) and 4 km west of Fishers Island, Connecticut (Figure III.B-10). Over the past 20 years the New London site has received about 8 million cubic meters of dredged material.

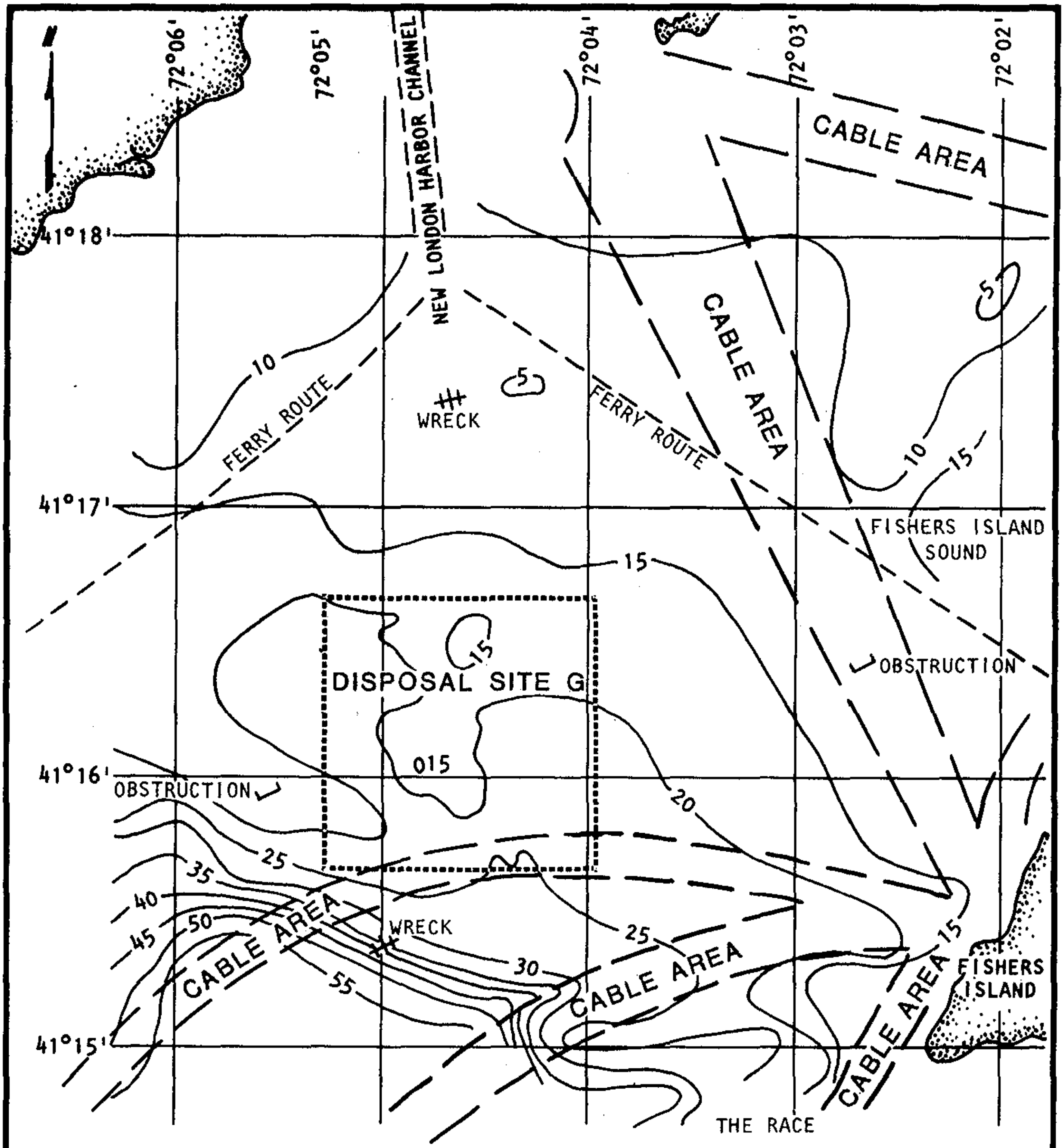
The New London disposal site has been subjected to extensive environmental monitoring programs since 1972 and the physical, chemical and biological effects of dredged material disposal at the site have been well documented (U.S. Navy, 1976; NOAA, and NMFS, 1977; Brown, 1978; NUSC, 1978). Investigations have included detailed bathymetric surveys, scuba diving and photographic surveys, sediment sampling and testing, and monitoring of physical and chemical water column parameters. A summary of select site physical and chemical characteristics is presented in Table III.B-1.

Sediments within the disposal site are primarily soft clayey silt (dredged material). Natural sediments in the area vary in texture but are generally composed of silty fine sands and muds containing 40 percent or less silt and clay. Chemical analyses of sediment samples from the area indicate enrichment of nutrients and certain heavy metals (cobalt and zinc) within one kilometer of the disposal site as a result of the disposal history (NUSC, 1977).

Water depths within Site G range from 15 to 25 meters. The natural bottom slopes gently to the south-southwest. A steep sided, northwest-southeast trending depression lies off the southwest corner of the site. Previous disposal of dredged material (primarily clayey silt) from the Thames River has created spoil piles in the south-central and north-central areas of the site. Past detailed site bathymetric surveys have shown conical dredged material piles at times reaching within 15 meters of the water surface. Recent sequential surveys reveal the dredged material piles to be subject to compaction and settlement resulting in broad, stable, well-placed mounds. Some winnowing of fine sediments from shallow portions of the mounds has been evident in photographic and scuba diver surveys (U.S. Navy, 1976; Morton, et al., 1975; NOAA and NMFS, 1977).

Due to the proximity of the New London site to a major harbor channel considerable maritime as well as military marine traffic prevail in the area. Ferry routes also exist northeast and northwest of the disposal site. The draft clearance of 15 meters should be maintained at this site (Silberman, 1980).

A submarine cable area crosses the southeast corner of the New London site (NOS Nautical Chart No. 12372, 1979). Other cable areas are located south and east, well away from the site boundaries (Figure III.B-10).



LOCATION MAP

EASTERN LONG ISLAND SOUND

SITE G - NEW LONDON DISPOSAL SITE

0 ½ 1 2 KILOMETERS

DEPTH IN METERS

DAMES & MOORE

FIGURE III.B-10

III.B.7.b Benthic Fauna

The sediment type existing at the site is predominantly mud. Natural sediments found in the area are sandy silt. Both support different benthic assemblages. Data collected within the disposal site indicate that the materials support a fairly diverse fauna (NOAA, NMFS, 1975; MAFC, 1974). Both the NUSC (1978) and NOAA (1978) data indicate that amphipods are quite common. Amphipods are generally accepted as fair indicators of non-stressed environments. The NOAA data found benthic diversity at the site to be within the higher diversity zone of the Sound. NUSC data from April 1978 resulted in low and high mean diversities for the disposal site and reference station respectively (Figure III.B-11).

A bivalve dominated the area in 1975 (NOAA, 1975); however, previous (MAFC, 1974) and later (NUSC, 1978) data show fewer than 5 individuals per sample. The most recent data (NUSC, 1978) indicated polychaetes were also common. Other common at the site include some "cosmopolitan" species. Organisms abundant in the sandy silt zones at the site are amphipods and polychaetes.

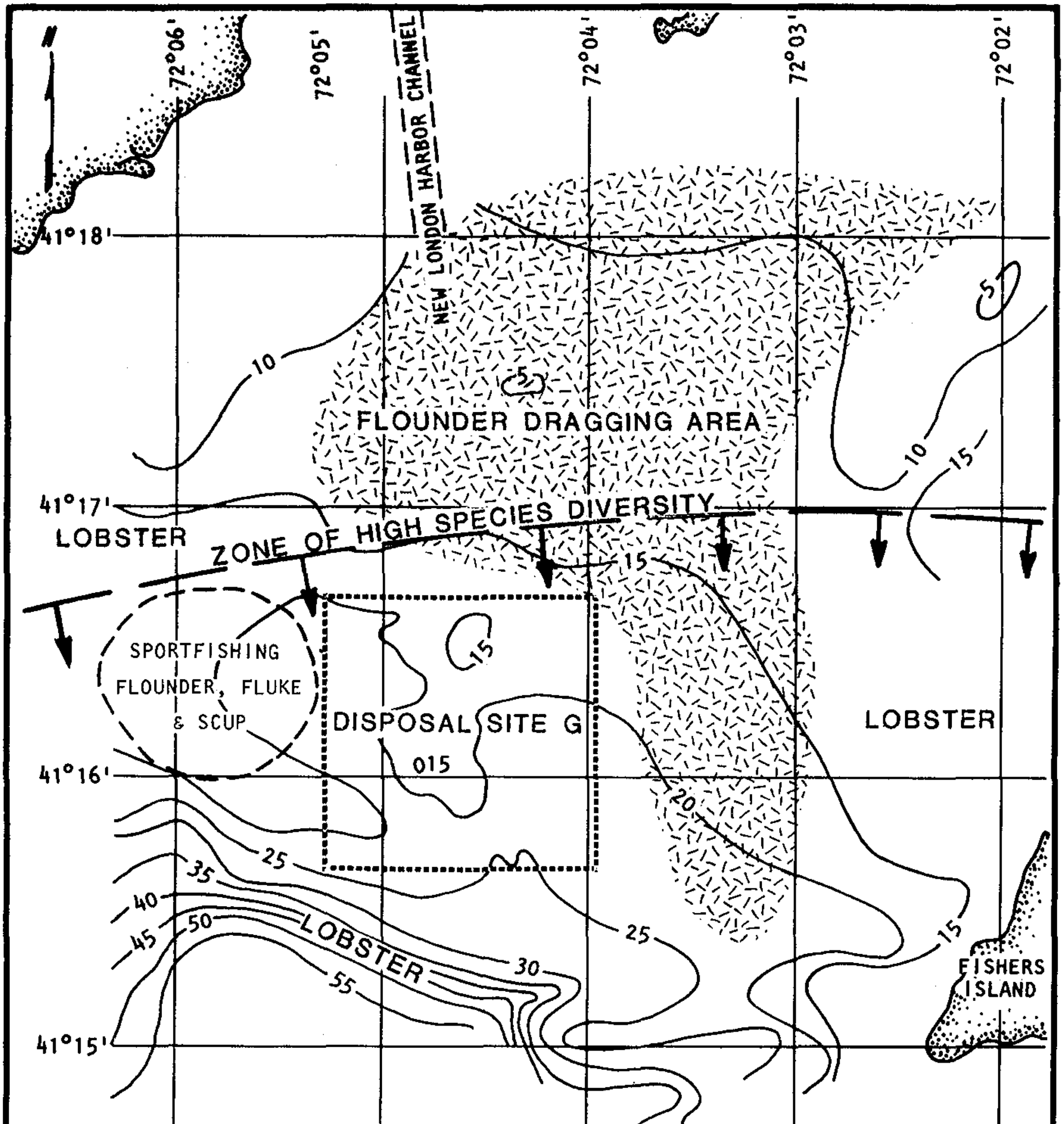
III.B.7.c Fisheries

Figure III.B-11 provides detail of fishery activity within the vicinity of the site. Lobsters generally occur throughout the region around the New London site; however, studies of lobster densities have shown that densities at the disposal site were about one third of those found in productive beds (NUSC, 1978). The lobster fishery here is not very large (the region consists of about 15 percent of entire Long Island Sound landings Connecticut DEP, 1979) and consists of small boats that begin close to shore in April and work out to areas of Plum Island and the Race by August, and large boats that move from the ledges along the Connecticut shore to deeper parts of the western Sound by the end of summer.

Pots are used heavily in the Race, where migratory lobsters are taken. At the disposal site 2-3 pot trawls are usually employed (NUSC, 1978). Although a lobsterman reported very good catches at the site when a pharmaceutical manufacturer disposed of organic wastes, a decline in lobster catches to the south of the site was noted after Navy disposal began (NUSC, 1978).

Other shellfisheries of the area are close to shore and away from this site. Other shellfish stocks that occur in the region include: bay quahog, ocean quahog, soft-shelled clam, surf clam, oyster, conch, moon snail, mussel, bay scallop and sea scallop, blue crab, rock crab, spider crab and horseshoe crab. The latter two are not commercially important and the blue crab, bay quahog and scallop, conch, moon snail, soft-shelled clam and oyster are restricted to shallow water estuaries, channels or other special habitat preference and do not occur at the New London site (U.S. Navy, 1976). Rock crabs are probably taken along with lobsters. The ocean quahog is taken east of Fishers Island at 41°15' latitude. The sea scallop has not been reported in data for the New London site.

Finfishing in the area is undertaken by both commercial and sport fishermen. The area north and east of the site is trawled for winter and summer flounder during the summer (NUSC, 1978). Some scup are also taken. About 10 boats may work in the area; however, only one or two use the area regularly. During the fall, blueback herring are also taken by the commercial fishery.



BIOLOGICAL RESOURCES

EASTERN LONG ISLAND SOUND

SITE G - NEW LONDON DISPOSAL SITE

0 1 2 KILOMETERS

DEPTH IN METERS

DAMES & MOORE

FIGURE III.B-11

The Race and Seaflower Reef provide much of the sportfishing activity, with bluefish, striped bass, and tautog being the most sought after species. Party boats and small sport boats have utilized areas 1.6 km northwest of the site and around the perimeter of the disposal mound for flounder fishing.

IV. ENVIRONMENTAL CONSEQUENCES

The environmental consequences of open water disposal of dredged materials can be related to the physical and chemical changes which occur as a result of the initial disposal operation and the long-term interaction of the deposited materials with the aquatic environment. Biological systems in the water column may be affected by the short-term physical changes (increased suspended particulates) or by the chemical changes in water quality following a disposal operation. Biological components of the water column may also be impacted by long-term releases of contaminants to the water column. Biological components may be affected indirectly as a result of changes in circulation, temperatures and salinity due to the physical modification in the bottom contours from dredged material accumulation.

Benthic organisms may be directly impacted by physical burial and habitat modification or from the longer-term physical and chemical interactions.

This section presents a discussion of Regulatory Guidelines and testing programs which address the evaluation of these potential impacts. Within this context, the general knowledge of specific impacts is presented followed by a discussion of the potential impacts at the candidate sites. The discussion of candidate site impacts is based on the information presented in Section III, Affected Environment.

IV.A Regulatory Guidelines

EPA has recently (44 FR 54221, September 18, 1979) released proposed final Guidelines regarding discharge of dredged or fill materials into the waters of the United States which lie inside the baseline from which the territorial sea is measured. These revised Guidelines reflect the 1977 Amendments of Section 404 of the Clean Water Act. The purpose of the section 404 (b)(1) Guidelines is to carry out the objective of the Act: to restore and maintain the chemical, physical and biological integrity of the Nation's waters. To accomplish this, the Guidelines were developed to control degradation of waters of the U.S. attributable to the discharge of dredged or fill material.

The key provisions of the Guidelines are as follows:

Alternative Sites

(a) The discharge of dredged or fill material does not comply with the Guidelines if there is a practicable alternative to the proposed discharge that is environmentally preferable and will have less adverse impact on the aquatic ecosystem.

(b) The discharge of dredged or fill material does not comply with the Guidelines if the damage will:

Water Quality

- o After consideration of dilution and dispersion at the disposal site, cause or contribute to ambient water quality conditions that violate any applicable State water quality standards, approved or promulgated by EPA under section 303 of the Act, or any applicable water quality criteria promulgated by EPA;
- o Violate any applicable toxic effluent standards or prohibitions under section 307 of the Act;

Biological Effects (Effects of Contaminants)	o	Result in the introduction outside the disposal site of toxic substances in amounts which cause destruction of organisms through acute or chronic toxicity or through physiological disturbance or which will result in potential adverse effects in a consumer organism through bioaccumulation of the substance in the aquatic organism;
Endangered or Threatened Species	o	Jeopardize the continued existence of an endangered or threatened species or result in the destruction or adverse modification of a habitat which is determined by the Secretaries of Interior or Commerce, as appropriate, to be critical habitat under the Endangered Species Act of 1973 unless an exemption has been granted by the Endangered Species Committee;
Marine Sanctuaries (Special Area)	o	Disrupt conditions and terms of marine sanctuaries designated by the Secretary of Commerce under Title III of the Marine Protection, Research and Sanctuaries Act of 1972.

(c) The discharge of dredged or fill material does not comply with the Guidelines if it is determined that the discharge will have an unacceptable adverse impact on the waters of the United States. Adverse impact will be based in an evaluation of:

Physical Effects	o	Substrate effects
	o	Suspended particulate effects
	o	Effects on water
	o	Current patterns and water circulation effects
	o	Normal water fluctuations effects
	o	Salinity effects
Special Areas	o	Effects on special areas such as sanctuaries, refuges, parks, natural and historical monuments, national seashores, wilderness areas, research sites, preserves, wetlands, mud flats, vegetated and unvegetated shallows, coral reefs and riffles and pools;
Biological Effects (Sensitive Organisms)	o	Effects on communities and populations or organisms dependent on water quality such as molluscs, fish, crustacea, food chain organisms, and wildlife and threatened and endangered species.
Use Conflicts	o	Effects on human use characteristics such as municipal and private water supplies, recreational and commercial fisheries, recreation, aesthetics and amenities.
Mitigating Measures	o	(d) *The discharge of dredged or fill material does not comply* with the Guidelines if the manner of discharge fails to sufficiently minimize where practicable any potential adverse impact to the aquatic ecosystem, including wetlands.

IV.B Regulatory Testing

The proposed 404(b)(1) Guidelines (44 FR 54221) dated September 18, 1979, require a material testing program if the general evaluation of dredged or fill material indicates that it is not sufficiently removed from sources of pollution to provide reasonable assurance that the proposed discharge material is not a carrier of contaminants. The term "carrier of contaminants" means dredged or fill material that is contaminated by chemical, biological or radiological substances in a form that can be incorporated into or ingested by and harm or otherwise contaminate aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment (40 CFR 230.3(i)). The purpose of the evaluation and testing procedure is to provide information in order to determine the potential short term or long term effect of dredged material on the physical and chemical components of the aquatic environment.

Potential environmental effects and the general testing techniques by which these effects are to be evaluated (40 CFR 230.23 (b)) include:

- Water Column Effects - Elutriate testing may be required to predict the effects on water quality due to release of contaminants from sediments in the water column. Bioassays may also be required.
- Suspended Particulate Effects - Suspended particulate phase bioassay testing may be required to determine the effect of uncontaminated suspended particulates on filter-feeding organisms or other vulnerable aquatic species as well to determine the bioavailability of toxics in this phase.
- Effects on Benthos - An appropriate benthic bioassay (including bioaccumulation tests) may be required.
- General Chemical - Biological Interactive Effects - Other testing may be required on a case-by-case basis to further evaluate potential environmental effects.

Similar testing is required for the evaluation of the disposal of dredged material in the ocean under Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972.

Considerations of the proximity of most of the major sources of dredged material for the Long Island Sound region to pollution sources and the general chemical character of these materials (Table I.D-9) indicates that specific testing would be required in most cases. The use of bulk chemical analysis to assess short and long-term impacts of disposal is technically unsound and unlikely to result in any level of environmental protection (Lee and Plumb, 1974; Brannon et al., 1976; Lee et al., 1978; and Lee et al., 1975). This is due to the fact that although various constituents may be present in the solid phase of the dredged material or adsorbed on the solid phase particles, and thus be recorded in the analysis of bulk chemistry (solids and liquids), it is the soluble and biologically available levels of the constituents that provide a measure of potential contamination such as is the case in the elutriate testing. In addition, bulk chemical studies cannot predict long-term net releases of chemical constituents from sediments or uptake and accumulation by various aquatic organisms (Hirsch et al., 1978).

A dredged material classification system based on bulk chemical analysis and physical characteristics, as proposed in the Draft Interim Plan (NERBC, 1979) for dredged material disposal in this region, cannot be used as the basis for the evaluation of the impacts of disposal. The Guidelines point out that the results of tests carried out on material similar to the material proposed for discharge may be relevant. Materials are considered similar if the sources of contamination, the physical configuration of the sites and the sediment composition of the materials are comparable, in the light of water circulation and stratification, sediment accumulation and general sediment characteristics. Thus, a general classification scheme using bulk chemistry data and the Guidelines criteria should be developed to identify similar dredged materials. However, the results of and tests conducted must be available for each similar category of material.

IV.C General Physical Effects

Physical effects include the smothering of benthic organisms, the disruption of a flow pattern, a salinity change, or a similar effect.

IV.C.1 Burial and Habitat Alterations

The impacts of open water disposal of dredged material are of greater significance to the bottom feeding benthic organisms because of their limited mobility and their specialized adaptations to specific sediment conditions (Pararas-Carayannis, 1973). Adverse environmental effects resulting from disposal were found to be from burial and suffocation (NOAA-NMFS, 1975) along with alteration of habitat. These impacts occur regardless of the levels of sediment contamination.

The burial of benthic organisms is dependent upon the quality of the material, the rate of disposal, settling rate of material and areal extent of disposal and settling (Pararas-Carayannis, 1973). Life habits (Kranz, 1972), morphological characteristics, species behavior and habitat (Maurer et al., 1978) are important in determining the ability of a species to escape burial. Among the pelecypods, infaunal siphonate and non-siphonate suspension feeders were more capable of escaping burial than epifaunal suspension feeders, mucous tube feeders and labial palp deposit feeders (Kranz, 1972). Some benthic species move freely through the sediments and are capable of migration through 10-50 cm of sediment whereas others may be ineffective at moving through even a thin sediment cover. Hirsh and others (in preparation) found that benthic organisms are best able to escape when sediments deposited are similar to those in which the organism occurs. In a study of vertical migration of several benthic species in simulated dredged material overburden, Maurer and others (1978) found that burrowing rates were also dependent on depth of cover and burial time. A disposal simulation model indicated that, from a single dump, the dredged material deposition would be greater than 2 cm only within 61 meters of the dump site. Death by physical burial or injury probably occurs to some proportion of the fauna directly at the dredge disposal location; however such effects would be localized to the immediate zone of impact of the descending material.

A study of a dredged material disposal site in Rhode Island Sound (Saila et al., 1971) concluded that (1) most mollusc species could reach the sediment surface after shallow burial; (2) less mobile forms were buried; (3) fish and lobsters could withstand high concentrations of suspended sediment for short periods, and lobstering on the perimeter of the disposal was good; (4) quahogs were killed by burial near the center of the disposal site, but not on the perimeter; and (5) amphipods were found throughout in great densities. In a study of a shallow-water dredged material disposal site in upper Chesapeake Bay, Cronin and others (1967), observed no significant losses of benthic organisms as a result of burial.

Population reduction as a result of burial of individuals under deposted dredged material is less likely to be the most significant impact mechanism for mobile benthic species such as lobster and crab. For these species, the loss or alteration of habitat can be the most important effect of dumping. Lobsters use rough bottom or areas or areas with crevices and ledges for shelter. Disposal of mud in such areas can reduce the degree of bottom irregularity and, therefore, the shelter suitability of the area. Disposal in relatively featureless areas can have a positive benefit in that some shelter in the irregularities of the disposal pile is provided where none previously existed. Some areas such as Eatons Neck have benefited greatly with respect to improved lobster fisheries in the vicinity of the disposal mounds.

Finfish are not expected to be impacted directly by burial. There may be some loss of eggs and larvae (especially demersal eggs, i.e., Pseudopleuronectes americanus, Menidia menidia and ammodytes americanus) by burial. However, this impact would not be significant to a specific fishery as none of the candidate sites are reported as critical spawning zones for any of the Sound fisheries (flounder, scup, or others).

Even though burial would result in mortality of many organisms in the areas receiving the deepest cover, recolonization is often rapid. Anderlini and others (1975) and Conner (1977) have found recolonization to occur within several months. Some opportunistic species such as Streblospio benedicti will colonize an area within several days. Richardson and others (1978) found that burial by dredged material reduced the number of benthic organisms present and increased the biological diversity in the Columbia River, Oregon. The reduction in numbers continued for at least 10 months after disposal. The impacts affected densities of more than half the organisms, with the other part being relatively unimpacted.

Certain species began repopulation soon after deposition, and one and a half years later sites were repopulated to previous levels. Previous experience at the New London disposal site indicates that some species are capable of rapid and vigorous colonization (Navy, 1979). McCall (1977) worked with colonization of infauna in Long Island Sound and found high numbers of infaunal benthos ten days after the placement of defaunated muds. Recolonization will occur at the disposal site and is dependent upon the characteristics of the material, the frequency of repeated disposals, local current regimes, benthic community compositions, season, and so on as to which species will settle and in what intensities. Areas of the Sound are continually recolonized after natural occurrences such as storms, increased sedimentation and destabilization of substrata with opportunistic species and species with nearby brood stocks probably prevailing.

Sediment types play a role in determining the species composition of benthic communities (Sanders, 1956, McNulty et al., 1962). Changes from an original sandy community to a muddy sediment community may result in development of a low diversity community due to the lack of availability of breeding stock for the different organisms which will tend to recolonize the new muddy bottom. Such organisms will not be available in the adjacent sandy areas.

IV.D Physical Effects at Candidate Sites

IV.D.1 Burial and Habitats Alteration

A detailed evaluation of substrate effects including potential changes in the nature (grain size of the material) and potential bottom contour changes would require an evaluation of the material proposed to be dredged and discharged at the sites. Since most of the material dredged from the Long Island Sound region consists of fine-grained muddy sediment, a general evaluation of the substrate effects can be made assuming disposal of this type of material. Of the seven candidate sites, Site D (Block Island Sound), Site C (Six Mile Reef) and portions of Site E (Eatons Neck East) have sandy bottom areas which would be significantly changed by disposal of muddy materials. This would result in a change in the benthic community to one characterized by greater numbers of deposit feeders at these sites. On the other hand, use of an area that has been used previously as a disposal site would greatly reduce the impacts associated with substrate changes. Most of the candidate sites have at some previous time been used, all or in part, as disposal sites (B, E, F, and G) and would have early recolonization (opportunistic) benthic species present.

Physical impacts at Site A should not be significant to the Sound ecosystem. To the west of the site is a discontinued disposal area and most of the area of the site is in moderate to low benthic species diversity. Lobstering takes place on the western half of the site and most of the area is within a trawling area for fluke, scup and flounder.

Physical impacts on the benthic community would appear to be negligible at Site B. Most of the area is in a moderate diversity zone with an area of low diversity towards the southeast. The southern quarter falls within the general lobster distribution; however, the major lobster fishery is about 5 kilometers to the south. The site bottom has already been changed since it is a discontinued disposal site. Popular recreational fishing sites lie about 5 kilometers north of the site, but no impact on that fishery is expected.

Site C lies within a general lobster distribution zone and is adjacent to a lobster fishery zone. Because of the higher population of lobsters relative to the other candidate sites, lobster burial may be more significant here. Benthic diversity is moderate in the region. The low population levels of benthic fauna other than lobsters suggest that local impacts on these species may not be significant.

Site D falls within an area of heavy commercial fishing activity; however, due to the mobility of the finfish resources and the large areal extent of the commercial fishery within Block Island Sound, no major impacts would be expected.

Site E, lying within western Long Island Sound, may be the most sensitive of the seven candidate sites. Due to the bottom topography and characteristics at this site, plus the fact that the western Sound is the most productive lobster region of the Sound, disposal here might have a greater impact on the benthos than at the other sites. The area is heavily fished for lobster and disposal could cause the most significant mortality to lobsters by burial at this site. To the south of the site is a trawler fishery for flounder and scup. Impacts on the finfish would be insignificant due to their mobility. Much of the western side of the site lies on the old Eatons Neck disposal site.

The impacts at both the New Haven and New London interim disposal sites are expected to be minimal. Burial of benthic fauna could result, but it is likely that rapid recolonization, as has been recorded for these sites, would occur. The fishing activity around these sites would appear to indicate that impacts from dredged material disposal are minor and short-term.

IV.D.2 Secondary Effects Due To Bottom Contour Alterations

Under some circumstances, the alteration of bottom contour as the result of depositional mounding of dredged material has the potential to result in secondary effects, such as changes in water circulation patterns and intensities or water fluctuations, which in turn may result in temperature and salinity characteristics of the water body. The potential for such effects is high in the shallow portions of bays and estuaries. However, because of the depth of water in which the candidate sites are found, previous disposal experience in Long Island Sound indicates that none of the candidate sites would experience any significant secondary effects as a result of bottom contour alterations.

IV.E <u>General Effects of Suspended Particulates (Turbidity)</u>

Suspended particulates consist of fine-grained mineral particles usually smaller than silt and organic particles. Potential impacts associated with greatly elevated levels of suspended particulates include:

- reduction of light penetration, which lowers the rate of photosynthesis and primary productivity of an area.
- reduction of feeding ability of sight-dependent species
- aesthetic impacts due to turbid plumes

Numerous studies synthesized by the Dredged Material Research Program (COE, February, 1979) indicate that, except in unusually environmentally sensitive areas such as coral reefs, turbidity is primarily a matter of aesthetic impact rather than biological impact. Changes in turbidity as a result of disposing of dredged material can take place in two distinct time phases, a short-term phase and a long-term phase. Increased turbidity in the short-term phase is most significant and is induced by increased suspended sediment loads in the water column, and near bottom during each period of disposal. This is the result of the introduction of dredged material into the water column and the lateral density flow or the turbidity cloud created during bottom contact. Changes in turbidity during this phase are usually short-term — from a few minutes to several hours. Turbidity plumes of this nature would be significant enough to locally reduce light penetration and primary productivity in the upper water column. Additionally, the feeding abilities of the species dependent upon sight for prey location might be impaired.

The long-term phase of turbidity effects is related to the interaction of water motion and dredged material which can result in resuspension of the settled sediments and the increase in turbidity after disposal is completed. Changes in turbidity in this phase are dependent on many factors including characteristics of water motion, strength of current, properties of the sediment particles, and water stratification conditions. The potential for impact due to this long-term phase would relate to the incremental increases beyond naturally occurring resuspension that would normally characterize a site. The addition of muddy dredged material to sandy bottoms which are in equilibrium with currents would provide such additional resuspension effects.

IV.F Effects of Suspended Particulates at Candidate Sites

IV.F.1 Short-term Effects

It is anticipated, based on field studies of dredged material disposal operations at the New Haven site (Gordon, 1974; Bokuniewicz et al., 1976) and the New London site (Navy, 1979) that none of the sites would experience significant short-term impacts as a result of individual discharge activities. Gordon (1979) found that 99 percent of the silty dredged material was transported rapidly to the bottom as a high speed turbulent jet. Turbidity returned to normal within an hour of disposal. Dispersion effects will be greatest at Sites C (Six Mile Reef) and G (New London) (Table III.B-1). Site D in Block Island Sound would have the next highest dispersion followed by Sites A, B, E and F. No significant impacts on aesthetic values due to the presence of the sediment plume are anticipated for any of the sites due to their general offshore location. The impacts of increased suspended particulates as they may relate to impacts on water column water quality or life is discussed below.

IV.F.2 Long-term Effects of Resuspension and Transport

With regard to increase in suspended particulates resulting from resuspension and transport out of the disposal site, prediction of bottom sediment movement and the mode of transport are based on an understanding of the interactions between sediments and the near bottom currents from tidal action, winds and waves.

Competency curves predicting the current velocity required to initiate transport for various grain sizes, are used by oceanographers and have been published in the literature (e.g. Hjulstrom, 1935; Sundbord, 1956; Bagnold, 1963; Inman, 1963; Sternberg, 1972). Table IV.F-1 shows the results of studies by Hjulstrom (1935), and Sternberg (1972) relating threshold water velocity at one meter above the bottom to grain size in millimeters. From Table IV.F-1 it can be noted that fine-grained silts or clays tend to require higher threshold velocities than sandy material. This is due to the increase of cohesiveness of the material for smaller grain sizes. Sternberg's results are parallel to, but typically higher than those of Hjulstrom's. Young and Southard (1978) estimated the erosion velocities in field and in laboratory tests for marine mud with varying organic content. Their results have shown that increase in organic content systematically increases the erosion thresholds in laboratory plume tests. Masden and Grant (1976) have studied the initiation of sediment motion due to wave motions and have concluded that the effect of the oscillatory, unsteady nature of wave-induced bottom currents on bottom sediments can be treated in a fashion similar to steady, uni-directional motions by adopting the Shields criterion. Shields criterion relates to the maximum bottom shear stress due to maximum bottom water velocity to grain size. Hence, the magnitude of wave-induced bottom current can be used to reflect the potential for sediment movement due to wave action.

The physical and chemical properties of the bottom material significantly affect the erosion threshold velocity. Increases in cohesivness, organic content, and grain size will require increasing erosional threshold velocities.

Table IV.F-1 also shows the minimum water velocity required for the subsequent transport of different sizes of materials once the sediment is set in motion. Although fine-grained materials (silts and clay) are more difficult to erode, once in

TABLE IV.F-1

EROSION AND TRANSPORT THRESHOLDS FOR INITIATION OF GRAIN MOVEMENT

	Minimum Water Velocity Required[1] (1 m above the bottom)			Minimum Water Velocity Required[2] (1 m above the bottom)
Sediment Type	Particle Diameter (mm)	Erosion (cm/sec)	Transport (cm/sec)	Erosion (cm/sec)
Consolidated clay	0.002-0.004	100	0.1	—
Silt	0.004-.04	27	0.1	29
Sand	.04-2.0	20	0.5	29
Granule	2.0-4.0	40	17	50
Pebble	4.0-5.0	60	30	70

(1) Hjulstrom, 1935

(2) Sternberg, 1972

motion, they can be transported by low currents. Bokuniewicz and Gordon (1977) noted that the cohesive silty dredged material at the New Haven Site did not erode with bottom current velocity in the range of 25-30 cm/sec while erosion and resuspension of similar materials did occur at Cornfield Point site which is characterized by maximum bottom tidal velocities of 40-55 cm/sec. Thus, it appears that an effective threshold velocity for resuspension of silty dredged materials is in the range of 35 to 40 cm/sec.

Bokuniewicz and Gordon (1977) noted that at about 25 cm/sec, tidal currents were capable of resuspending the uppermost fluffy, non-cohesive silty sediments with low organic content which characterize central and western Long Island Sound. Bioturbation can increase the water content of bottom materials. This increase in water content can decrease the erosional resistance of the materials (Rhodes, 1973). At present, no detailed data are available to quantify the change in erosional threshold velocities for different materials as a function of the extent of consolidation or bioturbation.

Since tidal currents at all of the sites have the potential to resuspend such non-cohesive silty material and since it probably represents a small fraction of the material deposited at the disposal site, the evaluation of resuspension at the various sites was conducted with reference to the apparent 35-40 cm/sec threshold velocity for cohesive, silty dredged material.

Site C (Six Mile Reef) in Eastern Long Island Sound has the highest maximum bottom tidal velocity (50-55 cm/sec) (Table III.B-1) and has a high potential for resuspension of such material. The presence of a sandy bottom in this area is consistent with this evaluation. The next highest maximum bottom tidal currents are found at the New London site (40-45 cm/sec). This is apparently a borderline case, suggesting a potential for occasional erosion and transport.

Recent monitoring studies at the New London Site (G) (NUSC, 1978) and (Massey and Morton, 1978) indicate that no measurable change has taken place in the dredged material mound, in the 1975-1976 period. The change in mound configuration to a relatively flat upper surface has been ascribed to consolidation (Navy, July, 1979). However, diver observations made between May and December, 1977 present evidence for some scouring and erosion of the dredge mound including a winnowing of fine surface material, flattened surface of cohesive clay material and extensive shell surface lag materials (Navy, 1979).

Thus, observations at New London are consistent with the evaluation that this area is a borderline case and some resuspension and erosion of deposited dredged material is occurring. At Site D in Block Island Sound, combined maximum bottom tidal currents (35-45 cm/sec) and wave-induced bottom orbital velocity (20-40 cm/sec) suggest that this is also a borderline case, and some resuspension and winnowing of disposed silty dredged material, comparable to the New London site would occur. Non-cohesive fine-sandy material would be resuspended by such currents to a greater extent.

Sites in western and central Long Island Sound (A, B, E and F) with maximum bottom tidal velocities in the range of 20 to 30 cm/sec would be the better sites to serve as effective containment sites for silty dredged materials. Natural bottom sediments and sediment accumulations for these areas are consistent with this evaluation.

Detailed studies of the physical components (sediments, bathymetry and currents) at the abandoned Eatons Neck Site by Bokuniewicz and others (1977) indicate that there is no physical evidence of significant dispersion of dredged material from the site.

With regard to the effects of increased turbidity due to resuspension, Site C would show a significant increase due to its normal low level of suspended particulates over the sandy bottom and the high potential for resuspension of deposited dredged material. Site D in Block Island Sound would have a moderate increase; especially in view of its sandy bottom. Although resuspension is occurring on a moderate level at the New London site, the incremental increase in suspended particulates is not high due to natural sources of suspended particulates in the adjacent areas. The potential impact on biological systems, due to resuspension and transport of deposited dredge material is treated below in a separate section.

IV.G General Short-Term Water Quality Effects

Most sediments in harbors and estuaries of industrial areas contain various levels of industrial contaminants such as heavy metals, organic pollutants, nutrients and oil and grease. These contaminants are present as a result of runoff; atmospheric fallout; industrial, urban and suburban effluent discharge; and wastes from both commercial and recreational vessels. The release of these contaminants may degrade water quality beyond levels which are considered safe for marine organisms. However, these contaminants are not very soluble in water under the conditions that normally occur in oxygenated uncontaminated surface waters. Therefore, introducing high concentrations of these contaminants into aquatic ecosystems will generally result in an equilibrium condition where most of the contaminants will be sorbed (adsorbed and absorbed) by suspended particulate material and then deposited on the bottom when the suspended material settles. The time necessary to achieve the equilibrium condition depends upon the physiochemical conditions in the aquatic system and the quantity and duration of the contaminant introduction (Burks and Engler, 1978).

Thus, the mere presence of chemical constituents in dredged material does not imply that adverse environmental impacts will occur as a result of aquatic disposal of that sediment. The impact on water quality and aquatic organisms is related to the concentration of mobile, biologically available sediment contaminants rather than the total concentration. The constituent may be present in a chemically immobile, biologically unavailable form. In most cases, the majority of naturally occurring metals will be in the crystalline lattice of minerals and will be essentially inert and biologically unavailable. Trace metals associated with parts of the dredged material other than the mineral crystalline lattice can also be essentially immobile and biologically unavailable. Most arsenic in sediment is usually asociated with highly crystalline iron and manganese oxides and is chemically immobile and biologically unavailable (Brannon et al, 1976). Chlorinated hydrocarbon pesticides and PCB's which occur in dredged material are usually tightly bound to the sediment. Only limited amounts of these contaminants are present in the sediment interstital water. (Burks and Engler, 1978)

One of the major factors in selecting the proper disposal site (e.g., well-mixed water, poorly mixed water, nearshore or upland) is an evaluation of the potential for change in the geochemical state of the disposal site. If the change in geochemical state is minor (i.e., disposal in well-mixed oxidized water with rapid settling to the bottom), potential for enhanced release of chemical constituents is minor. The following sections provide a synopsis of the potential impacts associated with contamination normally associated with dredged material disposal.

IV.G.1 Heavy Metals

The Dredged Material Research Program (DMRP) reports and other literature on laboratory testing (elutriate), theoretical considerations of heavy metal geochemistry, and the results of field studies summarized by Brannon (1978) and Burks and Engler (1978) indicate that dredging operations have the potential to temporarily mobilize or release some contaminants from the sediments. During disposal operations, the anaerobic sediments are mixed with aerated surface water, and a complex chemical interaction occurs. Heavy metals, such as cadmium, copper, chromium, lead, and zinc, are stabilized in the oxygen-free sediments as insoluble sulfides. When the sediments are oxygenated, these metals form oxides that are slightly more soluble than the metal sulfides. The reduced forms of iron and manganese in oxygen-free sediments are, however, more soluble than the oxides formed in the overlying water. As a result, immediately after disposal of sediments in oxygenated surface waters, iron and manganese hydrous oxides begin to coagulate and precipitate. The surface of the iron hydrous oxide coagulates has a strong affinity for other heavy metals and effectively sorbs or removes the slightly soluble metal oxides of cadmium, copper, chromium, lead, and zinc from the water column (Burks and Engler, 1978).

In general, water quality impacts due to open water disposal are not significant. Even when sediments are contaminated with cadmium, copper, lead, zinc, or cadmium, open-water disposal in sites with free circulation, such as in the candidate sites, should not release biologically significant quantities of toxic heavy metals for periods of more than a few hours. When such quantities are released, initial concentrations are usually below water quality criteria for marine and freshwater systems.

IV.G.2 Nutrients

Some nutrients, such as ammonium and phosphorus, may be released in open water disposal, but in most cases enough mixing is present to rapidly dilute these to harmless concentrations. Phosphorus is relatively nontoxic, but the portion of ammonium-N present as un-ionized ammonia can be toxic if elevated concentrations persist in an alkaline pH environment for an extended period of time. Releases of these contaminants would, however, exert minimal impacts under the conditions usually encountered at aquatic disposal sites. Elevated concentrations of the constituents are of short duration because of rapid mixing and are of low frequency due to the intermittent nature of disposal operations.

A potential secondary effect of disposal is the increase of inorganic nutrient-containing wastes in the water column, which could lead to an excess of photosynthetic production and possible phytoplankton blooms. These compounds include nitrogen, nitrite, nitrate, phosphorous and ammonium. The blooms, when moderate, add to the productivity within an area. However, in excessive populations they can lead to oxygen depletion when the organisms die off, fall to the bottom, decompose, and are broken up by bacteria, further intensifying oxygen utilization. Additionally, toxins may result with a decrease in community production, respiration or both. Toxin formations from blooms are also aesthetically displeasing, may cause irritation to swimmers, and may result in shellfish contamination.

Ammonia released during open-water disposal can be converted to nitrate by bacterial action if the receiving waters have adequate dissolved oxygen levels. However, this process may take several days depending on the physical-chemical conditions and presence of accumated nitrifying bacteria. Dilution by receiving waters is, therefore, the most important mechanism in the short term reduction of ammonia levels. (Burks and Engler, 1978)

Blom and others (1976) found only low-level releases of ortho-phosphate from most sediments. The amount of phosphorus in aqueous solution rapidly declined to insignificant levels in a matter of minutes due to sorption by iron hydrous oxide colloidal particles. Also, soluble phosphorus is sorbed by microbial organisms and primary producers such as algae and diatoms.

IV.G.3 Organics

Chlorinated hydrocarbons such as DDT, dieldrin and polychlorinated biphenyls (PCBs) are notorious environmental contaminants with wide distribution. Chlorinated hydrocarbons are only slightly soluble in seawater and are typically tightly bound to fine soil particles in a sediment-water system and may accumulate to high concentrations in sediments (Burks and Engler, 1978). Although the manufacture and/or disposal of such compounds has been stopped by Federal actions, sediments that have already been contaminated with organochlorine compounds will probably continue to have high levels of these compounds for several decades (Dennis, 1975).

Even though some dredged sediments contained high levels of chlorinated hydrocarbon pesticides and PCBs, no significant release of these materials into the water column was observed during disposal (Lee et al., 1975). PCB release was not detected in the field due to rapid mixing and dilution of the very small quantities released. Consequently, the release of chlorinated hydrocarbon pesticides and PCBs into the water column during dredging and disposal had little short-term impact on water quality. Dredged sediments from sites containing the highest oil and grease content tended to release the least chlorinated hydrocarbon pesticides and PCBs into the water column. In addition to the affinity for fine particles, low release of PCBs appears to be associated with increased levels of oil and grease in dredged materials and may explain the low levels observed in field studies (Lee et al., 1978).

In general, petroleum hydrocarbons (here including oil and grease) are similar to chlorinated hydrocarbons in that they are strongly bound to sediment particles, and they experience minimal release to the water column during disposal (Van Vleet and Quinn, 1977; DiSalvo et al., 1977). Similar results were obtained from laboratory tests (Engineering Science, Inc., 1977). Thus, short-term adverse effects of petroleum hydrocarbons in a subaqueous disposal site appear to be minimal (Pequegnat et al., 1978). However, if the organic material consists of a high concentration of crude or processed petroleum products, there is a possiblility of releasing persistent aromatic compounds to the water column which may have local adverse effects on marine ecosystems (Shelton and Hunter, 1975; Strosher and Hodgson, 1975).

IV.G.4 Dissolved Oxygen

Disposal of dredged material into ocean waters will probably result in a decrease in the dissolved oxygen (DO) concentrations in the water column for short periods of two hours or less after individual dumps. The decrease in concentrations as shown in field studies generally does not decrease to the point where marine organisms might become stressed. The reduced DO concentrations would occur only within the limited zone directly influenced by the descending plume. As such free swimming species can easily avoid the affected area. Depression of DO concentrations has more of an effect on less mobile bottom dwelling organisms. However, it is not expected that anoxic conditions would develop on the bottom unless oxygen saturation in the water column is low to start with. The following paragraphs further discuss the nature and effects of short-term reductions in DO concentration.

In disposal operations at the New London site, dissolved oxygen levels have been shown to return to predisposal concentrations from 15 minutes to 2 hours after disposal (U.S. Navy, 1979). In studies offshore Galveston, Texas, DO concentrations returned to pre-disposal levels within 10 minutes after the passage of the dispersal plume (Lee et al., 1977). NOAA (1977) reported that the DO content in the bottom waters at the New London disposal site dropped to about 48 percent of saturation and returned to the ambient 84 percent within 40 minutes, whereas the surface and middle waters were hardly affected. In another test they observed bottom water concentrations returning from 65 percent saturation to 96 percent saturation and again surface waters were unchanged. Experimental work performed by Lee and others (1975) has indicated that the oxygen demand occurring in the water column during the first hour of disposal from a wide variety of polluted dredged material types ranges from 1.6×10^5 to 2.5×10^6 milligrams of oxygen per cubic meter (mg O_2/m^3) of dredged material. Offshore Galveston, Lee and others (1977) reported the greatest DO drop was 1.7 mg/l; however at no time did the levels fall below 5.0 mg/l, the concentration at which many marine organisms might become stressed.

The potential for impact to dissolved oxygen concentrations will in all probability be greatest at the bottom of the water column. Where conditions of moderate to high levels of oxygen saturation exist, it is not expected that anoxic conditions will be produced even within the plume on the bottom. Oxygen concentrations did not go lower than 50 percent of saturation after disposal (U.S. Navy, 1979).

It has been suggested that disposal in waters with low levels of oxygen saturation could result in short-term periods of anoxic conditions within small pockets of the water column. However, dilution and mixing should appreciably confine these episodes. In addition, relatively oxygen-saturated water is held within the dredged material. These waters may thus aid in raising oxygen concentrations somewhat.

Lee and others (1977) have reported that travel time between dredging and disposal sites influences the oxygen demand. The longer the material remains in the scow, the greater the possibility for oxidation due to mixing in the scow. This would reduce the oxygen demand exerted on the receiving water. Additionally, Lee and his co-workers found that volume of material would also affect oxygen demand. The higher the sediment to water ratio the greater the availability of material to exert a demand on the water column. Thus, with longer travel times and smaller volumes there should be less DO depletion (Lee et al., 1975).

IV.G.5 Summary

As summarized by Burks and Engler (1978), constituents released to the water column from a broad range of sediments tested were ammomium, orthophosphate, manganese, iron, and suspended particulates. Ammonium was released in concentrations that could be considered toxic in areas of poor mixing. There was no release of other metals and nutrients, chlorinated hydrocarbons, and petroleum hydrocarbons in the dissolved state to the water column. It was found, however, that the sediments scavenged the water column of numerous constituents when fine-grained harbor sediments were dispersed in the water column.

The short-term impacts on water quality can be evaluated by the elutriate test. Field studies have generally shown the test to be a conservative procedure, generally overestimating releases observed in the field (Brannon, 1978). This characteristic is desirable from a regulatory standpoint as a safety factor to ensure no adverse impacts. Elutriate analyses of individual materials will indicate whether disposal can meet State and Federal water quality criteria.

IV.H General Long-Term Water Quality Effects

As discussed above, sediments tend to act as a sink for trace metals and organic contaminants. There is concern that these constituents may be remobilized back to the water column with the potential for impacts on water quality. An exensive laboratory investigation with long-term incubation testing (150 days) of contaminated dredged material (Chen et al., 1976) showed that, with the exception of iron and manganese, most of the metals were released in the ppb range under slightly oxidizing conditions, and with little increase or actual decrease under reducing conditions. Iron and manganese were found to be released several hundred times over the seawater background levels under reducing conditions, with iron in the range of 0.1 - 1 ppm, and manganese from 0.01 -0.1 ppm.

Nitrogenous compounds were released in substantial quantities from clayey-type sediments. Ammonia nitrogen and organic nitrogen can be released to the range of 10 ppm under anaerobic conditions. At this range of concentrations, the unionized ammonia fraction can reach toxic levels only in highly alkaline waters (EPA, 1976). Nitrate and nitrite were released to the same 10 ppm range under aerobic conditions. Silty and sandy-type sediments were observed to release at a level 2 to 10 times lower than that of clayey sediment. Brannon (1978), in a summary review of potential long-term release of contaminants to the water column, concludes that the magnitudes of contaminant release were such that little impact on water quality would be expected in the field.

The concentrations of orthophosphate were in the range of 0.1 to 0.8 ppm under most conditions. Soluble silica increased to 10-20 ppm. Chlorinated hydrocarbons were not observed even after three months of experimentation.

In field studies of disposal sites where evaluations of concentrations in the water column can be directly associated with only deposited dredged material as a source, Wright (1978) in Brannon (1978) indicates that no significant long-term elevation of organic contaminant concentrations have been observed.

The potential exists for a decrease in bottom dissolved oxygen as a result of the oxidation of deposited dredged materials. However, as a large portion of the demand in the dredged material is from slowly oxidizing refractory materials, it is not expected that significant effects on dissolved oxygen levels would occur in most uses. Also, a large fraction will be sequestered by burial and thus not available for use. Seabed oxygen consumption rates observed at a dredged material disposal site in the New York Bight (Thomas et al., 1976) suggest that as little as two percent of the daily input of oxygen demand from deposited dredged material contributes to seabed oxygen consumption after the settling of the deposited material to the bottom (Segar, 1977).

Pratt and O'Connor (1973) point out that benthic oxygen uptake rates appear to be limited by the diffusion rates of a) oxygen into sediments and b) reduced substances out of the sediments. Since these rates of molecular diffusion are many orders of magnitude smaller than any conceivable dispersion rate in the overlying water, they conclude that oxygen depletion in overlying water after emplacement is not a serious problem. In addition, once the deposited material becomes recolonized by benthic infauna, the burrowing activity within anerobic sediments will increase the depth of the oxygenated layer (Gordon et al., 1972). In this fashion, the COD will be satisfied over a prolonged period (days or weeks) and thus may be considered as long-term effect with no significant adverse impact.

Long-term laboratory incubation testing by Chen (1976) investigated dissolved oxygen of silty clay-type sediments. Laboratory results suggest that oxygen depletion in the overlying waters occurs when circulation of those waters is limited or if the dissolved oxygen concentration in those waters is low to begin with.

IV.I Water Quality Effects At Candidate Sites

The potential for environmental effects resulting from the disposal of dredged material in Long Island and Block Island Sound can be related to the general considerations noted above, the ambient water quality conditions and physical components of the system such as the tidal currents and density stratification of the water column which control mixing.

In their environmental baseline for Long Island Sound 1972-1973, National Marine Fisheries Service assessed the water quality of the Sound (NMFS, 1974). Using a number of indices (dissolved oxygen, nutrients, sediment organics, heavy metals and fecal coliform bacteria) NMFS found that westernmost Long Island Sound is exposed to a considerable contaminant loading. The next most contaminated areas were the coastal waters associated with several Connecticut urban areas. All of western and central Long Island Sound exhibited somewhat degraded water quality compared to the well-flushed eastern areas.

The most critical problem for the region is identified as the reduction of dissolved oxygen levels by contaminant loading in the western Sound including areas at Sites E and A. During summer stratification, bottom levels of dissolved oxygen fall well below the Interstate Sanitation Commission's criterion of 5 ppm for fish survival and passage of anadromous fish. NMFS cites reports of periodic fish kills that occur in this area. One dissolved oxygen related die-off in August, 1970 was estimated at 35,000 commercially valuable fish (mostly menhaden). Although it is recognized that pollution sources other than dredged material disposal are the primary source of pollutant loading in this area, the NMFS recommendations were that any activities, including dredged material disposal, which would potentially add to the stresses already present in this area by adding oxygen-demanding wastes, should be relocated or deferred if at all possible.

Although the general short-term and long-term impacts on water quality are not expected to be significant at the candidate Sites E and A, the small incremental stresses that may be placed on summer oxygen depletion in this area is of greater concern. Thus disposal at Site E (Eatons Neck East) and Site A which are located in this portion of the Sound, has the potential to aggravate the low levels of oxygen in bottom waters during the summer and increase the potential for fish kills.

The sites vary with respect to their degree of potential to effectively disperse initial and subsequent contaminant loads to the water column (Figure IV.I-1). Dispersion effects are greatest at Site C (Six Mile Reef) and the New London sites. Site D in Block Island Sound would have the next highest dispersion, followed by Sites A, B, E and F. The level of mixing available at the sites should provide sufficient mixing so that water quality criteria are not exceeded.

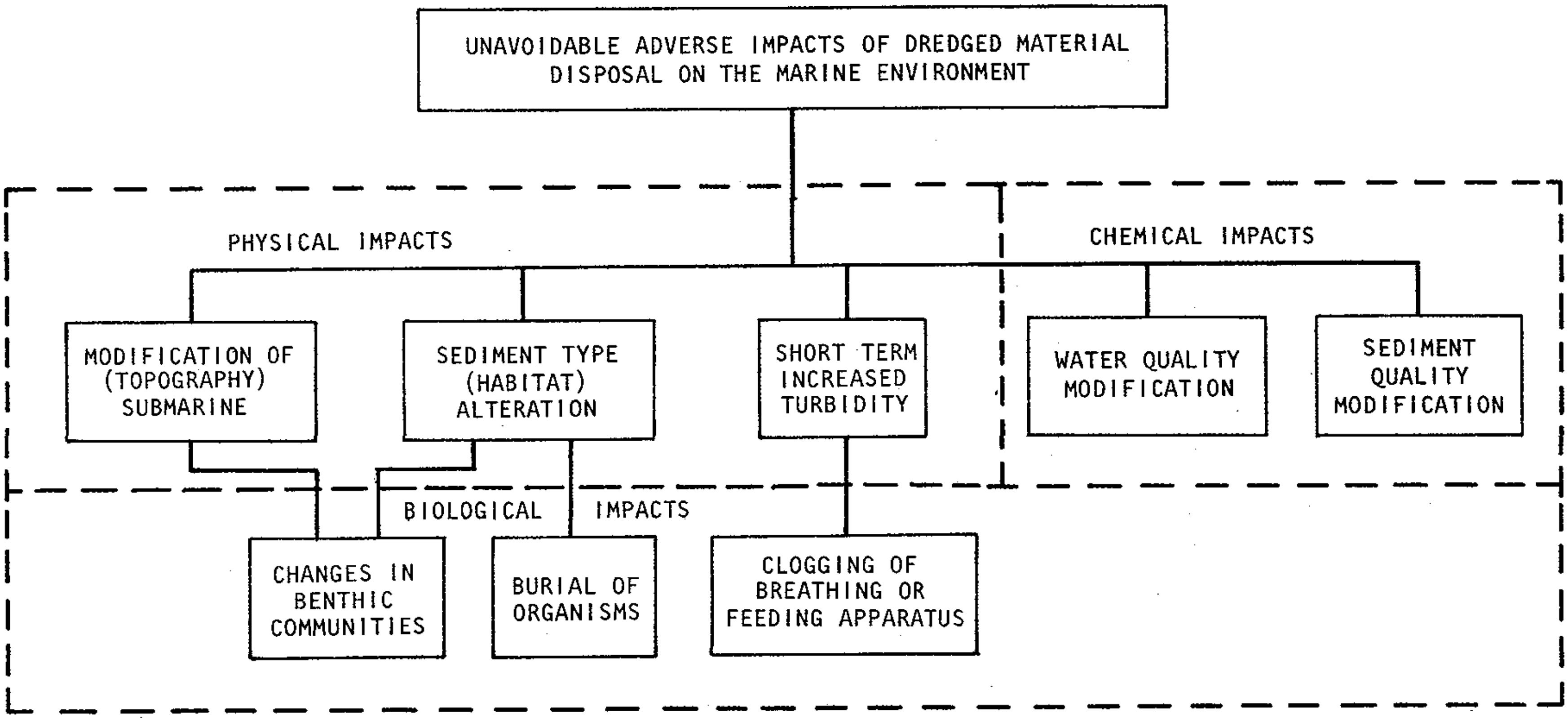
IV.J General Biological Effects

Potential biological effects due to the open water disposal of dredged material relate to the short-term and long-term physical effects as well as the potential adverse effects due to chemical contamination of the water and substrate. Potential impacts, both physical and chemical, are greater for communities in sensitive areas that contain components valuable to the ecosystem or food chain such as mollusc beds or nursery areas. The site selection methodology considered such valuable components of the ecosystem (Section III.B). In addition, special consideration was given to threatened and endangered species that may be affected by disposal activities. As discussed above, the most direct biological impact associated with open water disposal of dredged material is related to the physical effects. These are discussed above in Sections IV.C and IV.D. This section addresses the potential impacts on biological systems as a result of chemical contamination that may result from disposal.

IV.J.1 Biological Effects Due to Chemical Contamination

Dredged materials (e.g., taken from inner harbor channels near industrial discharges,) may contain chemicals which can be toxic to marine plants and animals. Disposal operations may result in the release of these chemical compounds to the aquatic environment. The effects of these contaminants can be classified as acute or chronic. Acute or immediately lethal levels would cause significant mortality to numbers of organisms exposed to given concentrations over a specific period of exposure. Chronic effects over a period of time could result in death to an organism. Sublethal effects include abnormal growth rates or behavior, inability to feed effectively or unsuccessful breeding. To the extent permitted by the state of the art, expected effects such as toxicity, stimulation, inhibition or bioaccumulation may best be estimated by appropriate bioassays. The realized toxic effects of contaminants which may be present in dredged material are as dependent upon the given form of the toxic substance as on the composition. Toxic substances may be bound into soluble molecules, sorbed to particles, or found in organic complexes which are unable to act as toxins or to be assimilated or accumulated by marine organisms.

Although some data are available on both acute and chronic doses of certain toxic substances for a few marine organisms, field verified doses for most substances are unknown (Pequegnat, 1978). The principal classes of pollutant-related toxic substances are heavy metals, chlorinated hydrocarbons and petroleum hydrocarbons. Examples of data on the effects of each of these groups of toxins are found in EPA (1973 and 1976), Hansen (1976), Michael and others (1975), and Parrish (1974). Results indicate that the range of concentrations that may detrimentally affect marine organisms vary from the ppm to ppb range for the most toxic. The long-term effects of these substances are also dependent upon their persistence in the environment in a bioactive form, and to a very great extent upon the particular species in question.



PHYSICAL, CHEMICAL AND BIOLOGICAL IMPACTS WHICH MAY RESULT FROM THE DISPOSAL OF DREDGED MATERIAL IN LONG ISLAND SOUND AND BLOCK ISLAND SOUND

DAMES & MOORE

FIGURE IV.I-1

Toxic dose level determinations are complicated by the fact that particular species may actively concentrate specific elements or compounds with no ill effects. This bioaccumulation may be for specific metabolic purposes (copper in some crustaceans: Green, 1963) or of unknown function (vanadium in some tunicates: Prosser and Brown, 1961). Quite frequently doses of toxins which are acutely toxic to predators are maintained with no ill effects by toxic prey, and toxins used by predators have no ill effect when the predator consumes the prey just poisoned. For these reasons, it is not possible to make broad generalizations about the levels of specific substances which will be broadly detrimental to a marine community.

IV.J.1.a Short-term Water Column Effects

Typically, the short-term impact of dredged material disposal through the water column has been considered negligible (Section IV.G). In general, no toxicities were observed for liquid and suspended particulate phase bioassays for sensitive aquatic organisms at concentrations representing field dilution conditions, even with limited dilution (Shuba et al., in preparation; Lee et al., in preparation). In addition, the welfare of water column organisms is considered through the elutriate test evaluations with regard to water quality criteria (see Sections IV.G and IV.H) These criteria have been established based on numerous tests of toxicity and sublethal effects on aquatic organisms. In addition, since disposal at a site is not a continuous activity and dispersion rapidly dilutes the released contaminants, short-term acute toxicity or bioaccumulation by aquatic organisms is most unlikely (Lee et al.; Wright, 1978; Holliday, 1978).

IV.J.1.b Short-term Benthic Organism Effects

Because benthic organisms are in close contact with potentially contaminated sediment for longer periods of time than pelagic organisms, the impact of disposal on such organisms is likely to be more evident (Brannon, 1978).

Shuba and others (1978) found some degree of toxicity to shrimp tested during solid phase bioassays with channel sediments in industrialized areas contaminated with kepone and sewage and chemical plant effluents. In studies of contaminant uptake in benthic organisms, no clear trends of accumulation or magnification were shown for heavy metals (Hirsch et al., 1978). Uptake of chlorinated hydrocarbon pesticides, PCBs and volatile or midmolecular weight oil and grease were not observed in benthic organisms. Monitoring of heavy metal uptake in mussels and clams affixed to the experimental platforms and suspended one meter above the bottom has been conducted at the New London dump site since March, 1977 (Watson et al., 1978). The only significant variation occurred in the trace concentrations of metals in mussels. Increases in trace metals, especially nickel, during the winter of 1977-1978 corresponded with disposal operations, low water temperature and high river outflow. It was not determined whether the elevated levels could be safely related to disposal. At any rate, soon after dredging ceased, concentrations of most trace metals in shellfish had returned to pre-disposal baseline levels.

In an extensive study to determine heavy metal availability to the benthos, Neff et al. (1978) found significant accumulation of metals from sediment to occur in less than 27% of different metal-species-sediment combinations. The study also found little evidence to support the premise that bulk-sediment metal composition could be used to estimate the environmental impact of sediment-sorbed metals on the benthic community. Availability was rather related to the chemical forms of the metals in the sediment and varies from one metal to another and between species of benthic organisms. In cases where as statistically significant accumulation of a metal occurred, the uptake was quantitatively marginal and of doubtful ecological significance (Neff et al. 1978).

The same study also found salinity influenced the relative availability of different heavy metals to benthic invertebrates. Replicate exposures under identical conditions often yielded contradictory results, indicating the possibility of seasonal variations in the ability of animals to accumulate heavy metals from sediment (Neff et. al., 1978).

IV.J.1.c Long-term Benthic Organism Effects

Biological impacts over several years following dredged material disposal on benthic and epibenthic organisms are largely unknown (Brannon, 1978). In assessing long-term effects of exposure, consideration must be given to the possibility and significance of the cumulative effect over several generations of such potential effects as impaired reproductive ability, behavioral modifications and other sublethal effects. These sublethal effects may result from bioaccumulation of contaminants.

A summary of the chemical and biological effects of contaminants commonly associated with dredged material is found in Connor et al. (1979). A review of the literature indicates that the knowledge of the availability to benthic organisms of contaminants contained in sediments is considerably restricted. There is some evidence both for and against correlations of contaminants concentrations in the sediments with concentrations in the associated benthic animals. Ecological effects of PCB's can be found in Fisher and Wurster (1973), Mosser et al. (1972) Fisher et al. (1974) Hansen (1976), Duke et al. (1970), and Hansen (1974). Michae et al. (1975) reported on effects of petroleum hydrocarbons on benthic community composition. Sublethal effects of petroleum hydrocarbons are also reported in Mironou (1970), Wilson (1970), and Bellan et al. (1972). The concentrations resulting from the effects reported above are generally much greater than those which are found after initial mixing and which are also regulated by EPA water quality criteria which were established to provide safeguards against such possible effects. DHEW (1972) and Roberts et al. (1978) report on studies concerning bioaccumulation factors. These studies indicate that in aquatic organisms the major concentration of PCB's occurs in the direct accumulation of PCB's from the water and that the classical "food chain magnification" is relatively minor. The fish and plankton data from the North Atlantic reported by Nisbet and Sarafin (1972) in that plankton and plankton and euphausid data of Elder and Fowler, (1977) are consistent with this hypothesis, residue levels are higher than fish levels, suggesting direct accumulation rather than food chain transfer. Harvey et al. (1973) data also offer no support for food chain magnification of PCB's among gilled organisms.

Peddicord, (1978) suggests that the effects of suspended sediments in fluid muds were more significant than those of contaminated sediments. Although the concentrations in test sediments were lethal, they were much greater than those levels found in the field. The availability of heavy metals is influenced by salinity and is dependent upon the chemical species of the sediments and the particular biological species (Neff et al., 1978). Leatherland et al. (1973) reported a uniform occurrence of mercury in different trophic levels. Food chain transfer was a likely source of mercury contamination in menhaden since mercury concentrations in their viscera were greater than in the rest of the fish; however, there was no evidence of strong food chain intensification (Cocoros and Cahn, (1973). Accumulation of mercury was not ascribable to biological activity (Williams and Weiss, 1973; Knauer and Martin, 1972).

Although these long term effects are not clearly understood, insight into the general problem can be achieved through the results of monitoring studies at disposal sites. The potential for uptake of contaminants can be evaluated through the bioaccumlation testing procedure.

Lee and Jones (1977) did not find evidence for harmful bioaccumulation of mercury, cadmium, selected pesticides, or PCBs in fish and crabs taken from the Mud Dump in New York Bight. This could be due to the relative mobility of the species tested, which may not have had sufficient residence time at the site to demonstrate significant bioaccumulation.

Wright (1978) has summarized the results of monitoring at five open water disposal sites located around the nation, including the Eatons Neck disposal site in western Long Island Sound. These studies suggest that disposal did not appear to have any lasting effect on sediment chemistry. Small changes in dissolved oxygen, metal and nutrients did occur but did not appear to be large enough to have a significant impact on the benthic community. There was virtually no evidence of uptake of contaminants at the site. Wright (1978) points out, however, that these results can represent at best only intermediate-term impact. Data on long-term impacts (several generations or biological years) are not available. At the Eatons Neck site, however, some years had elapsed from the end of the 75 years of disposal to the study period and these results may reflect "long-term" effects. At Eatons Neck, benthic organisms did not differ in abundance or species composition between the disposal and reference sites, although sampling distribution may not have been adequate to demonstrate this unequivocally. Lobsters (found in great abundance at the site) did not show any elevated levels of metals. It seems likely that disposal has had a beneficial effect upon lobster populations due to rubble and other material forming suitable substrate for these semiburrowers. Further, the benthic community must be sufficiently productive to support this shellfish population.

IV.J.2 Biological Effects Due to Chemical Contamination at Candidate Sites

Issues of acute toxicity, sublethal effects and bioaccumulation are primarily dependent upon the nature of the dredged material to be deposited. Contaminated materials would have similar short-term impacts at each of the candidate sites. Long-term impacts could be more variable at the candidate sites. Site C, and to a moderate extent, Sites G and D (Section IV.F.2), because of their greater potential for resuspension and net transport, have the potential to release contaminants outside the disposal area. Site E, which is adjacent to prime lobster fishing areas in western Long Island Sound, might be most sensitive to long-term contaminant release by impacting important commercial lobster areas. However, as discussed above, previous disposal at the Eatons Neck site had no apparant long-term adverse impact on this area. Site E is also nearest shellfish beds (1.5 km to the north). Additionally Sites G, A and D are in areas of commercial fishing which could be impacted by the long-term release of biologically available contaminants. Consequently, monitoring of impacts at selected disposal sites over several years following disposal is recommended.

IV.J.3 Threatened and Endangered Species Effects

No adverse impacts are anticipated for the endangered species listed in Table III.A-2 from dredged material disposal at the candidate sites.

Not much is known of the movements of the shortnose sturgeon when it is outside of the coastal rivers and lower estuaries. The population in the Connecticut River which may possibly wander out through the Sound, is rather mobile and would be accustomed to waters with increased levels of suspended sediments. Any impacts from dredged material disposal would be unlikely. The sea turtle and marine mammals whose range would extend into the Sound are also very mobile and would be likely to avoid areas of disposal. Any impacts would probably be the result of damage due to increased boat traffic.

The Bald Eagle and Peregrine Falcons are birds which may pass over the study area during their seasonal migrations. However, they do not utilize the area on a long-term basis or for breeding. The likelihood of being impacted here by the uptake of contaminants (insecticides, pesticides) is very small. The osprey, which breeds in the area, is dependent on fish as a food source. Chlorinated hydrocarbons have been considered as a major reason (besides habitat destruction) for the reduction in osprey populations in coastal regions of the U.S. like Long Island Sound. Dredged material to be disposed in Long Island Sound will have to pass certain bioassay/bioaccumulation tests, in which chlorinated hydrocarbons are considered.

IV.K Public Health

An array of pathogenic bacteria derived from sewage sludge exist in marine sediments (U.S. Navy, 1979). Sewage treatment outfalls are probably the primary source of pathogenic bacteria which may be present in dredged materials. High total and fecal coliform bacteria are generally found associated with sediments rather than in the water column (Rittenberg et al., 1958).

Testing of sediments to be dredged from the Thames River indicates relatively low levels of bacteria (U.S. Navy, 1979). Total and fecal coliform bacteria, streptococci, staphylococcus and salmonella were tested to indicate comparative pathogenic bacterial contamination. Apparently these pathogens can tolerate the conditions (temperature, salinity, pH) at the disposal sites in Long Island Sound. Birely and Buck (1975) tested for coliform at the New Haven disposal site and found levels higher than those reported for the Thames River.

Staphylococcus populations can be present in shellfish. Some strains of staphylococus can cause enterotoxins which can lead to food poisoning. Salmonella are also pathogenic to man and their presence represents a health hazard (U.S. Navy, 1979).

The presence of heavy metals, chlorinated hydrocarbons, and petroleum hydrocarbons also represents a health hazard to man. Certain concentrations can be mutagenic, teratogenic or carcinogenic. Their presence within shellfish and finfish below health hazard levels can cause tainting and can lead to short or long term loss of potential fisheries.

Under the National Shellfish Sanitation Program, which is administered by the States and the Food and Drug Administration (FDA), potential contaminations to shellfish (in particular for Long Island and Block Island Sounds, the surf clam and the ocean quahog) are monitored and steps are taken to prevent impacts to public health by closing contaminated beds. The regional Interim Dredged Material disposal sites (including the New Haven and New London sites) do not present a potential for shellfish contamination since no beds are present in these areas. This is also true for the remainder of the candidate sites under consideration here. With regard to potential contamination of lobster areas, this does not represent a health hazard since they are cooked, not eaten raw, and are thus not associated with bacteriallly-related health problems.

IV.L Effects on Special Areas

Due to their unique ecologic, historical, educational, recreational and/or scientific importance, the following type of areas are singled out with respect to evaluation of potential effects of open water disposal of dredged materials (404b(1)):

- Sanctuaries and refuges
- Parks, national and historical monuments
- Natural shores
- Wilderness areas
- Research sites
- Other preserves
- Wetlands
- Mud flats
- Vegetated and unvegetated shallows
- Coral reefs
- Riffles and pools

None of the Candidate Sites are located within sufficient distance of these areas to cause impacts. Consideration of such special areas was incorporated into the site selection procedure (Section II.B). Site D does occur in a general region of scientific research but disposal would not conflict with this research.

IV.M Economic Impacts

The potential economic consequences associated with using any or all of the seven recommended areas as future disposal sites would result primarily from changes in unit dredging cost ($/cubic yard). The unit dredging costs would, in turn, be affected by the change in the transportation component — the costs incurred in barging the material from the dredging area to a designated disposal area. Unit transportation costs ($/cubic yard/mile) are a function of the type of equipment used: size of the barge, size of the tug, towing speed, number of barges towed, and accompanying capital and operating cost (e.g., fuel cost, labor, depreciation, and repair).

The unit transport costs are constant up to a distance of approximately 32 kilometers. Beyond this point, unit transportation costs begin to increase due to overtime costs, as well as the greater likelihood that offshore weather conditions will inhibit or stop dumping activities.

The primary determinant of unit dredging costs is the ability to maintain continuous operation of the dredge. Longer hauling distances would increase unit dredging costs as additional tugs and barges are required to keep a dredge in continuous operation. A longer round trip time greatly reduces the number of daily trips a tug and barge can make to the disposal site. This in turn requires the presence of additional tugs and barges to provide additional carrying capacity. The net result is that capital and operating costs must go up, or if additional equipment is not available, productivity diminishes while the dredge idles until a barge becomes available.

The unit transportation cost for a commonly employed tug/barge combination has been estimated at 6.2¢/cubic yard/mile. This unit transportation cost was based on information obtained from interviews with dredging contractors, an examination of historical dredging costs in Long Island Sound and on current prices for barges, tug rental rates, fuel and labor costs. It is recognized that unit transportation costs for smaller pieces of equipment used in small harbor and marina dredging would be significantly higher. The above function assumes the use of an 1800 hp tug towing one 2000 cubic yard hopper barge at 6 statute miles per hour. The mileage refers to one-way distance to a disposal site, but allows for the round trip distance.

Unit dredging costs are also affected by the project size. An examination of unit dredging costs incurred on Corps projects utilizing open water disposal in Connecticut over the 10-year period 1968-1977 yields a very approximate inverse relationship between job size and unit cost (correlation coefficient of -.3). That is, unit dredging costs do decline as the project size increases. This is consistent with information gained from talks with dredging contractors, and the expectation that larger jobs allow the use of larger capacity dredges and barges which result in economies of scale in terms of productivity. All other things being equal (material type, transport distance, disposal site), the larger the job, the lower the unit dredging costs are likely to be.

The issue of job size has significant implications concerning the incidence of economic impacts on private projects utilizing Long Island Sound disposal sites under a Federal permit. Between 1968 and 1977, private dredging projects averaged approximately 16,800 cubic yards in size, excluding the dredging of the Navy's submarine base at New London (Energy Resources Company, 1979). Over the same period, Corps of Engineers jobs (new work and maintenance) averaged approximately 110,000 cubic yards in size. Given that there are economies of scale in dredging (including the transporting of spoil to open water disposal sites), it is apparent that private sector unit dredging costs were higher in the Long Island Sound area during this period.

The size and unit cost differentials between Corps and non-Corps dredging projects indicate that changes in the location of disposal areas would have a proportionally more severe economic effect on private dredging jobs. One major reason that private jobs are more expensive is the small size and shallow depth of the municipal, non-corps maintained harbors and marinas located along the Sound. These physical constraints limit the size of the equipment that can be used. For example, a 2,000 cubic yard bottom dumping barge draws between 15 and 18 feet of water when loaded and has dimensions of approximately 200' x 50'. This precludes its use in smaller harbors and marinas and means that smaller, less efficient equipment must be used. Similar size constraints apply to the use of large mechanical dredges on small jobs.

A comparison between the different dredging and transport modes showed clearly that the smaller unit (500 cubic yard barge, three cubic yard mechanical dredge) had higher unit transportation costs of approximately ($.14/cubic yard/mile). Thus, the smaller average size of many private dredging projects necessitates the use of less efficient equipment (economies of scale in dredging and transport cannot be captured), and the higher unit transport costs imply a greater increase in unit dredging costs as the distance to a disposal site increases.

Changes in unit dredging costs as affected by changes in the transportation component will affect two primary sectors in the study area, the small local marine trades and the firms involved in waterborne commerce. The small local marine trade firms include marinas, recreational boating dealers, and local dredging firms. Organizations engaged in waterborne commerce include terminal companies, shippers, petroleum storage and distribution firms, and municipal port authorities. Both of the above sectors are dependent upon periodic dredging (either by private means or the Corps of Engineers) to help maintain the economic viability of their operations. The importance of waterborne commerce to the Long Island region is indicated by the fact that approximately 26.6 million metric tons of cargo were handled in Long Island ports in 1977, about 15 percent of the total for the entire Port of New York (U.S. Army Corps of Engineers, 1977).

The use of the present three disposal sites in Long Island Sound has had an adverse economic impact on water-oriented businesses that depend upon periodic maintenance dredging for their economic viability. The closing down of some of the close-in, historic dumping areas in the Sound, particularly Eatons Neck, has contributed to the economic decline in the recreational boating industry in Connecticut in recent years (Berrien, 1979). An example of this increased cost of doing business for marinas is shown in the estimates received by the Cedar Island Marina in Clinton, Connecticut for necessary maintenance dredging. The estimate for disposal of 20,000 cubic yards at the old Clinton site (currently closed) was approximately $49,000 as compared to $82,500 at the Cornfield Shoals site and $178,000 at the New Haven disposal site. For this marina, the difference between disposal at the Clinton site and Cornfield Shoals amounts to an additional annual expense of $33,500, a 68 percent annual increase in the largest component of their total maintenance cost.

The closing of historic disposal areas in the Sound and the use of the three current regional disposal sites has also had an adverse impact on small local dredging companies in the Long Island Sound area. The increased haul distance to disposal areas has decreased the competitiveness of the small dredging company in that they do not have the additional equipment necessary to keep their dredges in continuous operation. Similarly, the small pieces of equipment needed to service the small harbor and marinas along the coast are generally not capable of capturing economies of scale in transporting the material and their unit dredging costs have risen significantly. Small operators have had to branch into other areas of work, lost revenues as marinas have found maintenance dredging too costly to do as frequently as they have in the past, or have affiliated with other firms to retain economic viability (Rudd, Molloy, 1979).

The size and type (adverse or positive) of economic impact associated with the potential use of the seven recommended sites as disposal areas depends on how many of the sites would in fact be used. The use of only one of the recommended sites would create a situation worse than the existing situation. The average distance from any potential dredging project to the disposal area would increase over the present average, thus increasing transportation and unit dredging costs. Conversely, the use of all seven sites recommended in this report as dredge spoil disposal areas would be likely to have a positive economic impact on water dependent economic activities in the Long Island Sound area. Marinas, marine contractors, dredging companies, and concerns involved in waterborne commerce, all of whom depend on periodic maintenance dredging, would benefit as the average distance to the nearest disposal site would (in most instances) be less than the current distances to the three regional sites. The exceptions would be those in which disposal characteristics would require disposal at a site whose physical characteristics would minimize potential environmental impacts.

The use of all seven of the recommended areas would not be likely to increase the cost of dredging carried out by the Corps of Engineers as part of their responsibility in maintaning navigable waterways. The transport distances would certainly not increase over current distances, and in some instances could decrease. The location of the proposed sites in Long Island and Block Island Sounds means that the additional investment that would be required to undertake continental shelf disposal would not be necessary. Similarly, the high transport costs associated with a 96 or 120 kilometer one-way trip would not be incurred.

The recommended Block Island Sound site would provide a disposal area for dredging work done in Rhode Island. The closing down of the Brenton Reef and Brown's Ledge disposal areas off Rhode Island has created a substantial backlog of much-needed dredging work in Rhode Island.

> "The dredging and dredged material disposal impasse is creating severe economic problems in Rhode Island. Dredging must be undertaken soon in several areas along the Providence commercial waterfront if this area is to remain competitive with other ports and harbors along the eastern seaboard. The lack of disposal areas for this material has already limited or indefinitely delayed the development and expansion programs at the Providence Port Authority and several private corporations dependent on navigable waterfront ..." (Seavey and Pratt, 1979).

The precise economic impacts are difficult to judge because future estimates concerning the location of projects relative to disposal sites are difficult to make. The key issue is to what extent future transportation costs for the disposal of dredged material within the Long Island Sound region would change. The recommended sites are all within Long Island and Block Island Sound coastal waters. Sites A, E, C and D would provide disposal locations for sections of the Sound that are not presently near any of the three regional sites. In particular, Sites E (western Long Island Sound) and D (Block Island Sound) may provide opportunities for the disposal of dredged material from projects that have not been completed partially because of high transportation costs.

The economic impacts of hauling dredge spoil to open ocean sites near the continental shelf would be very significant. The environmental suitability map indicates a potentially acceptable disposal area (high minus suitability class) located just south of the 40° 31' north latitude. This area lies approximately 75 statute miles from New London, Connecticut.

Transporting dredge spoil to this site would require a round trip of 150 statute miles, and a commonly employed tug/barge combination would take a minimum 21.5 hours to make the round trip. It is likely that more time would be required as the average towing speed would decline due to the increased probability of encountering unsuitable weather and higher waves.

The unit transportation costs would be higher than 6.2¢/cubic yard/mile because of overtime costs for the crewmen and the federal inspector. Similarly, slower average towing speeds would increase transportation costs as more fuel would be consumed per trip because of longer round-trip times. Assuming the unit transport costs rise to 7¢/cubic yard/mile after eight hours, such a trip would require transport costs of approximately $4.42/cubic yard. As a comparison, transport costs to take dredge spoil from New London to site G (eight miles) would be $.49/cubic yard.

Unit dredging costs would also rise because of several additional factors. First, disposal at this distance from shore would require additional capital investment in tugs and barges capable of withsanding the weather conditions and seas that are more likely to be encountered on long trips. There are few large bottom dumping barges on the east coast currently capable of making this trip (McPhillips, 1970). Only large, ocean-going tugs (ABS certified) could be used on such trips and these vessels are significantly more expensive than smaller, non-ocean-going tugs. Secondly, there are certain to be more working (hauling) days lost per year because of inclement weather than would be lost in the more protected waters of the Sound. A tug operator will want to be certain of favorable weather before venturing on such a trip, so as to avoid being caught in heavy seas 40 or 50 miles offshore and towing a barge. Finally, the length of such hauls would make it more difficult and expensive to maintain dredge productivity by supplying additional tugs and barges. It would not be financially or logistically feasible to supply the necessary equipment to keep a dredge operating continuously with a 22 hour round-trip time between the dredging site and the disposal area.

The net economic effect of disposing of dredge spoil at or near the Continental Shelf would be to at least double (and likely triple) unit dredging costs. The incidence of this impact would be particularly severe on private businesses with small, intermittent dredging requirements. They are already feeling an economic pinch with the present arrangement of three regional disposal areas. They simply could not afford dredging which required disposal far at sea. For the Corps of Engineers, the expenditures necessary to maintain the navigable waters of the Long Island Sound would rise significantly under this option. From 1968 through 1977, the average one-way haul distance for Corps projects in Connecticut using open water disposal sites was 6.3 miles (Engineering Resources Company, 1979). Use of a deep water site with any degree of frequency would certainly raise this average haul distance appreciably. Even limited deep water disposal of unsuitable or highly contaminated spoil would significantly increase their expenditures.

V. UNAVOIDABLE ADVERSE IMPACTS AND MANAGEMENT TECHNIQUES (Mitigating Measures)

V.A Introduction

The specific impacts of dredged material disposal will be a function of the chemical and physical character of the dredged material as indicated by appropriate testing procedures as described in Section IV.B. For the purpose of discussion, the most significant impacts associated with open water disposal of dredged material would be from fine-grained materials that are contaminated to a high degree (within the limitations of the testing noted above) by organics, especially PCB's; trace metals, especially mercury, cadmium and lead; and nutrients.

Techniques for managing open water disposal as part of a systematic plan of implementation can mitigate adverse short-term and long-term effects (Gambrell et al., 1978). This section outlines the adverse impacts associated with open water disposal and presents management techniques designed to mitigate these impacts. Table V.A-1 provides a summary of the impacts and related mitigating measures discussed below.

V.B Short-Term Water Column Impacts

As discussed in Section IV, within the framework of the conditions set by the elutriate testing, no significant impacts are expected with regard to water quality including turbidity from suspended particulates. The one exception is the potential for aggravating oxygen-depleted conditions at Eatons Neck East (Site E) and at Site A during the summer. In addition, release of nitrogen during such periods may stimulate local algal blooms, which often die off, further loading the bottom waters with oxygen-demanding materials at these sites.

This potential impact could be avoided by limiting disposal of oxygen-demanding materials to cool periods not characterized by such low oxygen saturation levels and times when blooms will not be stimulated.

V.C Physical Substrate Impacts

Use of the seven sites as dredged material disposal areas would result in a range of potential values lost due to direct burial of benthic organisms, fish eggs and larvae. Losses would range from high at Eatons Neck East (Site E) to moderate at Six Mile Reef (Site C) and Block Island Sound (Site D). Losses at Bridgeport East (Site A) would range from low to moderate, and would be low at New Haven (Site F), New London (Site G), and Branford (Site B) (Section IV.D.1).

In general, care should be taken at all sites to plan diposal operations to avoid sensitive spawning periods and periods of larval development. Rhodes et al. (1978) suggest that for deeper areas of the Long Island Sound, (depth greater than 20 m) where storm effects are minimal, disposal be accomplished between January and April, a period of low recruitment and low bottom temperatures. Disposal should not occur from May through December, a period of intense recruitment and population growth. Rhodes et al. (1978) also point out that disposal can be managed by yearly

TABLE V.A-1

SUMMARY OF IMPACTS AND MITIGATIVE MEASURES FOR CANDIDATE SITES

Candidate Sites	Short-Term Water Column Effects	Short-Term Physical Effects on Benthos	Long-Term Effects on Aquatic Ecosystem Due to Chemical Contamination
A. Bridgeport East			
Impacts	Potential problem of summer oxygen depletion and potential for nitrogen release to stimulate agal blooms	Low to Moderate	Low (for contaminants) Moderate for oxygen depletion
Mitigative Measures	Limit disposal to cool periods when low bottom D.O. not present	Avoid disposal during spawning periods	Capping highly contaminated materials with clean cover; capping of high oxygen demanding materials
B. Branford			
Impacts	Not Significant	Low	Low (Confinement site)
Mitigating Measures	N.A.	Avoid disposal during spawning periods	Capping of highly contaminated materials with clean cover
C. Six Mile Reef			
Impacts	Not Significant	Moderate	High (Dispersal site)
Mitigating Measures	N.A.	Use of techniques for limiting area of bottom impact (increase bottom roughness and lower insertion speeds); Avoid disposal during spawning periods	Restrict disposal to clean materials (spread fine organics)
D. Block Island Sound			
Impacts	Not Significant	Moderate	Low-Moderate (Moderate confinement site)
Mitigating Measures	N.A.	Use of techniques for limiting area of bottom impact (increase bottom roughness and lower insertion speeds); Avoid disposal during spawning periods	Capping of moderately to highly contaminated material with clean cover
E. Eatons Neck East			
Impacts	Potential problem of summer oxygen depletion and potential for nitrogen release to stimulate agal blooms	High	Low for contaminants (Confinement site) moderate for oxygen depletion
Mitigating Measures	Limit disposal to cool periods when low bottom D.O. not present	Avoid disposal during spawning periods	Capping highly contaminant materials with clean cover; capping of high oxygen demanding materials
F. New Haven			
Impacts	Not Significant	Low	Low (Confinement site)
Mitigating Measures	N.A.	Avoid disposal during spawning periods	Capping of highly contaminated materials with clean cover
G. New London			
Impacts	Not Significant	Low	Low-Moderate (Moderate confinement site)
Mitigating Measures	N.A.	Avoid disposal during spawning periods	Capping of moderately to highly contaminated materials with clean cover

pulses of disturbances from disposal at the appropriate seasons, to maintain an increased level of productivity of opportunistic species over a period of years. Significant impacts to spawning and nursery areas however, have been avoided by incorporating consideration of these sensitive areas into the siting analysis.

Muddy materials dumped at Sites D and C and the sandy portions of Site E would probably result in recolonization by polychaete-dominant communities different from the existing communities. Measures to mitigate such effects would include limiting disposal of muddy materials to the muddy bottom areas of Eatons Neck East (Site E) and allowing only sandy dredged materials to be deposited at Sites C and D.

As pointed out by MACF (1974) an exception to the concept of placing similar grain size material on similar disposal site sediments may be justified for the case in which fine-grained and highly organic, but otherwise uncontaminated, dredged material could be placed on low-organic content sandy areas in order to enhance productivity. In such cases, the concept of confined disposal, developed for most of the impact considerations in this EIR, would give way to a concept of spreading the materials over a larger site area. Assurance would be necessary that contamination from PCBs and other organohalogens, petroleum hydrocarbons, and trace metals, all of which have an affinity for fine-grained organic sediments, were not present. For typical harbor dredged materials exposed to numerous pollution sources, this would be unlikely. However, uncontaminated organic fine-grained materials may characterize some future new dredging work from deeper, uncontaminated layers and would be appropriate for spreading at the sandy areas of Sites D, C and E.

V.D Long-Term Water Column and Benthic Effects Due to Chemical Contamination

The major variables in the long term release of contaminants have been identified and discussed in detail by Gambrell and others (1978) as:

- o The degree of and nature of the contaminants.
- o The level of biological productivity or sensitivity of the disposal area.
- o The degree of hydraulic and geochemical stability of the disposal site area.

Of particular concern are dredged materials contaminated with significant levels of organohalogens, especially PCBs; or trace metals, especially mercury, cadmium and lead. In addition to the regulatory testing programs, environmental risk can be reduced to low levels if site conditions provide confinement in low energy hydraulic settings with minimal effects of storm currents upon the remobilization of these contaminants into adjacent areas.

As discussed in Section IV.F.2, candidate sites in western and central Long Island Sound (Sites A, B, E and F) are effective confinement sites which would retain depositional mounds of material in place. A layer of non-cohesive fluffy silty material, similar to the naturally occurring "fluff" layer in the Sound, would also be found on the disposal mounds. Some slight and infrequent resuspension of this upper layer may be expected.

If low cohesion fine-grained materials with high water content pass testing for open water disposal, but have high allowable levels of the contaminants of concern, capping of such deposits with uncontaminated coarser-grained material is recommended. Covering will help to isolate contaminated material from occasional dispersion by strong currents (Gambrell et al., 1978). Also, the increased distance coupled with the immobilization processes within the clean layer will effectively prevent passive transport of trace amounts of contaminants from the depression or mounds by diffusion.

Pratt and Connor (1973) have evaluated the results of the capping process using a theoretical one-dimensional diffusion model for two general cases of contaminated dredged material and capping material grain size and conclude that unconsolidated sand cover over muds is an effective solution.

The unconsolidated sand can be spread evenly enough to cover a large area and the diffusion effects are favorable in confining contaminants to subsurface horizons. Pratt and Connor conclude that, in general, clean cover material should be coarser than the contaminated dredge material to be covered. Unfavorable concentrations can occur in upper layers when the cover is finer. Such capping with uncontaminated cover is also recommended by EPA in the September 18, 1979 404 b(1) Guidelines.

Capping as a mitigative measure has been conducted by the New England Division, U.S. Army Corps of Engineers with regard to the disposal of dredged material. These materials are fine-grained muds from Stamford Harbor that have high water content and contaminant concentrations which were a cause for concern regarding the potential long term effects on water and benthic systems should they be mobilized. The disposal site is the New Haven site, which has demonstrated good confinment characteristics but which may receive occasional storm currents capable of resuspending such non-cohesive fine-grained materials. To reduce environmental risk to a low level, the area was capped with cleaner materials from New Haven Harbor. Two piles were initially formed with Stamford material. The piles were then capped with mud from the New Haven Inner Harbor going on one pile and sandy material from the New Haven Outer Harbor going on the other. Monitoring is ongoing at both piles to record the effectiveness of the capping procedure relative to the performance differences between the silty and sandy cover materials. Such procedures are consistent with all considerations appropriate to disposal site management (Holliday, 1978). Such site management schemes also make use of the precision dumping techniques for controlled dumping using fixed buoys and precision navigation, as well as predictive analysis of placement of dredged material in open water disposal (Bokuniewicz et al., 1978). These methods and prediction techniques have been evaluated and field tested at a number of sites, including the New Haven site, and have been shown to be effective. Preliminary monitoring indicates that such techniques are workable methods of reducing the environmental risk of disposal of such materials. Continued monitoring will form the basis for further evaluation of this program. Care should be exercised, however, in the evaluation of the elutriate testing and liquid and suspended particulate bioassay results for such a program, to insure that the limits placed on mixing and dilution by the required point dumping procedure are conservatively included in the assessment of impacts on water quality and water column biota.

Since long-term exposure of bottom oxygen-demanding substances may provide a critical added stress on the bottom areas of Eatons Neck East (Site E) and at Site A, *capping with low oxygen-demanding clean sandy materials is also recommended* for these sites as a mitigative measure. McKeown, Benedict and Locke (1968) report that a thin (1 to 7 cm) layer of sand over pulp sludge reduced oxygen uptake by 35 to 43 percent.

Capping would be appropriate at Sites B, E and F only for high risk contaminated materials such as the fine-grained muds from Stamford Harbor. These materials have high water content and contaminant concentrations which are of concern because of potential long-term effects on water quality and benthic systems should they be remobilized. Moderately contaminated cohesive materials have low environmental risk at these sites due to good confinement characteristics. Moderately contaminated materials deposited at New London (Site G) and Block Island (Site D) would provide increased environmental risk due to moderate potential for resuspension. In addition, Sites G and D are in areas of commercial fishing and could be affected by long-term release of biologically available contaminants. Dredged materials with only low levels of PCBs, mercury, cadmium and lead should be disposed of without a capping program at these two sites. The high mobility expected at Site C would seem to preclude an effective program even for capping, and disposal at this site should be limited to relatively clean materials which, upon spreading, will provide no potential for long-term uptake or other effects on the ecosystem.

It should be pointed out that the successful implementation of a regional management system for mitigation of adverse impacts will require controls in the integration of project types, testing and scheduling on a regional basis such as occurred in the Stamford disposal at New Haven. A possible limiting factor will be the availability and timing of projects offering suitable capping material, especially sand. Such suitable sources of dredged sand appear to be limited, with most of the material being muddy from the main portions of the harbors. In addition, some sources of sand may be more beneficially used for other constructive purposes, such as beach nourishment.

V.E Management Summary and Recommendations

V.E.1 Western Long Island Sound

If disposal in western Long Island Sound is considered necessary, Site A offers some advantages, especially with regard to lobster fishing, over Site E. Only those projects which, as a result of severe economic impacts on small operators due to added transport costs, and which comply with the mitigating measures outlined for Site E, should be considered for disposal at Site E. In general, small volumes of low oxygen-demanding (sandy) materials deposited at appropriate times of the year and using techniques to limit the impacted area to suitable portions of the site is recommended.

Capping would be appropriate at Site A when high risk materials such as produced in the Stamford project are to be disposed of. Migative measures, including capping to lessen the potential of bottom oxygen depletion, would be appropriate for materials consisting of low to moderately contaminated, oxygen-demanding sediments. Use of the New Haven Site (Site F) for uncapped disposal of such material is preferable when the economics and/or availability of suitable capping material prevent capping operations at Site A.

V.E.2 Central Long Island Sound Projects

The use of Site B appears to offer no clear advantage over continued use of the New Haven Disposal Site for this region. Since New Haven is currently being used, it is recommended that New Haven site be continued as the regional disposal site for this area. Continued use of capping programs, such as used in the Stamford project, are recommended for high contaminant level projects only. Other general seasonal mitigative measures discussed above are also appropriate for all sites. Site C would be appropriate for use only as a spreading or dispersal site for uncontaminated materials, perhaps from new work projects (lower portions) in this region. Thus, for typical contaminated materials in the eastern portion of the Central Sound, use of the New Haven or New London sites is recommended. Since projects with moderate levels of contamination would require capping at New London but not at New Haven, due to differences in resuspension potentials, the economics of transport and capping must be considered together with the availability of suitable capping materials to determine which site would be more appropriate. In addition, the precision dumping required in capping operations limits to some degree the water column volume available for dilution. Therefore short term water column effects should be evaluated with respect to this dilution limitation when specific disposal sites are selected.

It has been suggested by MAFC (1974) that for barren sandy bottom areas in Long Island Sound such as at Site C, that benthic community diversity could be enhanced by the dispersed disposal (spreading) of fine-grained, uncontaminated dredged material. The associated organic content of these materials would provide an enhancement to the benthic fauna and local food web. The area of Site C is characterized by high bottom currents which will tend to disperse such deposited materials and increase the levels of bottom turbidity which would be an adverse effect on the benthic fauna. Much of this material would tend to be dispersed to the mud accumulation areas in the Central Basin. However, due to bioturbation, the fine-grained material would become reworked into the upper portions of the sandy sediment with the positive effect of increasing the organic content of the sandy sediment. Additional information regarding the extent of turbidity effects from such a spreading scheme and the actual sediment changes and effects would be required to assess the advisability of utilizing such an approach at Site C. However, in view of the likely contamination of most fine-grained dredged material, only deeper new work may be fine-grained and uncontaminated. These deeper materials will tend to have higher cohesion and lower water content and thus will pose problems for disposal techniques which would allow even spreading over wide areas. However, should the need arise for use of a disposal site for considerable volumes of fine-grained uncontaminated material, consideration should be given to Site C, for a dispersal site, pending the further evaluations noted above.

V.E.3 Eastern Long Island Sound and Block Island Sound Projects

The New London site is recommended for use for projects in this area, together with the use of appropriate measures discussed above including capping of dredged material containing moderate to high levels of contaminants. Detailed information for Site D in Block Island Sound is not presently available, but it appears to have some disadvantages over the New London site, such as habitat alteration impacts associated with deposition of mud on sand bottoms.

Since most Rhode Island project sources are located in the eastern portion of the state, the use of Site D would still represent an economic burden for these major sources. Evaluation of the environmental suitability of open water disposal sites further east in Rhode Island Sound, planned by New England Division in the near future, will provide a more meaningful evaluation upon which to recommend open water disposal sites for this region.

V.F Monitoring and Research Studies

Implementation of management practices and continued review of projected impacts should be continually assessed through a monitoring and research program. The monitoring studies conducted to date, such as the DAMOS studies, indicate that short-term (2-3 years) effects of controlled disposal are confined to the disposal area. Strict enforcement of Corps of Engineers permits issued pursuant to Section 404 of the FWPCA to insure that no short-dumping will occur is considered an important pre-requisite to assurance of environmental safeguards.

Trip monitors which verify the course of the scow and record the location where dumping takes place are being tested by the Coast Guard. The operational reliability of such systems is yet to be proven. When proven, such systems should be used along with Corps of Engineers inspectors to insure that dumping can only occur at designated locations.

The Draft Interim Plan for disposal of dredged material in Long Island Sound (NERBC, 1979) calls for disposal area monitoring to assure that applicable water quality criteria are not being violated. To provide this assurance and also to increase our understading of the animal-sediment interactions in relation to long-term impacts of contaminations, the following parameters are recommended in the Interim Plan for a minimum program:

- Chemical and physical analyses of sediments giving special attention to "tags" including molluscan assemblages in surficial spoil and recent sediments as well as deeper and geologically older sediment in both disposal and reference areas.

- Bathymetry, including profiles through spoil mounds of interest and bathymetric reference stations (annually).

- Reproductive and settlement success of the macrobenthos and/or key components of the macrobenthic communities.

- Visual inspection of disposal and reference areas via SCUBA.

- Potential toxicant body burdens in key components of infaunal or sessile components of the benthic communities.

- Bio-accumulation studies of selected food chain organisms.

Monitoring programs for each disposal site should be standarized and coordinated in terms of sampling dates, data acquisition, and data reduction procedures. With the exception of disposal area bathymetry, physically, chemically, and biologically conservative parameters should be sampled at least twice a year, in early summer and in late fall (NERBC, 1979).

It is also recommended that animal-sediment interactions and bioaccumulation/biomagnification studies be conducted for existing harbors environments in order to provide an understanding of the transfer mechanisms that are presently operative for known levels of contamination. Such information would be of assistance in evaluating the bioassay and bioaccumulation test results, since it would provide indications of the long-term intergrated effects of exposure of specific contaminated sediment on various trophic levels in the aquatic food chain.

The above listed recommendations should be implemented in addition to the existing monitoring and mitigation measures currently being used. These include:

- The intensive site monitoring activities of the DAMOS Program.
- The scheduling of dredging activities to avoid spawning periods of fish and shellfish native to the particular area.
- The continued testing of dredged material under the 404 (b) (1) guidelines as well as for in-house research work on material behavior.

VI. RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

A detailed assessment of the short-term use of the aquatic environment for the disposal of dredged material compared to the maintenance and enhancement of long-term productivity would depend on the individual project and the selected disposal site. In general it is recognized that benthic habitats at disposal sites may be initially displaced and recolonization communities may be characterized by lower diversity. However, long-term productivity may not necessarily be compromised and may in fact be enhanced. For example, the irregular mounding which characterizes the cohesive disposal chunks and blocks at disposal sites such as at Eatons Neck offers an attraction for lobster habitat. In addition, as discussed in Section V, Rhodes and others (1978) have suggested that seasonal and yearly scheduling of disposal activities can be managed to effect an increased level of productivity of recolonizing opportunistic species.

Opportunity may also exist to increasing productivity of some low diversity sandy areas by disposing of clean dredged material with increased levels of fine grained organic materials over such areas.

VII. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IF THE PROJECT WERE IMPLEMENTED

The following sections summarize the commitment of resources that would be involved if the disposal sites recommended in this report became operational.

VII.A Energy Consumption

It is estimated in Table I.D-8 that beginning in 1980 anywhere from 0.7 to 1.3 million cubic yards of dredged material will be disposed of annually in Long Island Sound. The range in the amount of disposed material is due to materials from dredging work in the New York District. These materials are currently being disposed of in the New York Bight, but they could conceivably be deposited in the recommended western Long Island Sound site. The amount of petroleum consumed in hauling the material to the sites will be primarily a function of the travel distance between the dredging operation and the disposal site, which is in turn a function of the location of the dredging projects in the Long Island Sound region relative to the recommended sites.

The use of the sites recommended in this report would not result in any significant increase in fuel consumption when compared to the current amounts. The use of Site A would result in a decrease in the average haul for dredging projects in western Connecticut. As an example, the current Stamford-New Haven dredging project results in a 51 kilometer trip (one-way) from Stamford Harbor to the present New Haven disposal area. In contrast, the distance to recommended disposal Site A (located off Bridgeport) would be only 32 kilometers (one-way), (assuming the material were suitable). This would result in a saving of approximately 1,200 liters of fuel per disposal trip. The use of Site E (the western Long Island Sound site) would be limited to acceptable material, but would also result in a fuel saving, as dredged material from western Long Island Sound must now be barged to the New Haven disposal site.

The use of the sites recommended in this report would result in fuel consumption levels similar to those that would occur under the Draft Interim Disposal Plan. The use of Sites A and E would result in fuel savings when compared to the Draft Interim Plan, which does not recommend the interim use of any western Long Island Sound site. This fuel saving would be offset by the transporting of some of the dredged materials coming from the Connecticut River to the New London site (G).

Future fuel consumption can be estimated by examining the projected dredging amounts requiring open water disposal as indicated in Table II.D-8. This estimate will be for work projected to occur in the New England Division of the Corps of Engineers. The spatial distribution of projects along the coast was based on projections contained in the Reconnaissance Report, Dredged Material Containment In Long Island Sound by the Energy Resources Company (1979). It is assumed that all material from the Connecticut River Mouth and North Cove areas will be deposited at the New London site (Site G). The unit transportation costs and fuel consumption rates used previously served as the basis for this estimate.

It is therefore estimated that approximately 667,400 liters (4,200 barrels) of fuel would be consumed annually in transporting the projected dredged material requiring open water disposal to the sites recommended in this report. This consumption would be significantly higher if dredged materials from New York projects sources were transported to any of the recommended site. However, it is likely that this would result in a net decrease in regional fuel consumption as it would to transporting dredged material to western Long Island sites would require significantly less fuel than transporting dredged material to the New York Bight.

VII.B Financial Commitments of the Federal Government

Between 1968 and 1977, the New England Division spent approximately $6.1 million in 1979 dollars for federal maintenance and improvement dredging in Connecticut requiring disposal in Long Island Sound. This yields an average unit cost of $3.15/cubic yard, based on an average haul distance of 10 kilometers (one-way). Using this average cost as a base, along with an average haul distance of 22.5 kilometers to the sites recommended in this report, the average annual Federal dredging expenditure for work done by the New England Corps of Engineers would be approximately $1.7 million. Disposal of dredged spoil from New York District projects would mean at least an additional federal expenditure of $1.55 million annually. This would be an additional expenditure of federal funds for disposal at sites recommended in this report but it would not result in a net increase in total federal dredging expenditures. The New York District would likely spend more than this annually if they continued to dispose of dredged materials from their western Long Island Sound projects at the New York Bight as opposed to using sites A or E. Using this average cost as an indicator of the costs that would be incurred if disposal operations were to use any or all of the seven recommended sites, the estimated annual average federal expenditures for dredging requiring disposal in Long Island and Block Island Sounds would be between $2.2 million (0.7 million cubic yards) to $4.1 million (1.3 million cubic yards).

VII.C Manpower Commitments

The staffing requirements for the disposal phase of mechanical dredging consist of eight persons on a tug and one tender on the barge, as well as one federal inspector per disposal trip. Staffing requirements for dredges vary depending upon the type (hydraulic vs. mechanical) and size of the dredge employed. Additional labor would be needed for Corps supervision and the processing of permits.

VIII. LIST OF PREPARERS

FIRM:	DAMES & MOORE Consultants in the Environmental and Applied Earth Sciences 6 Commerce Drive Cranford, New Jersey 07016
PRINCIPAL:	Robin, E., Associate Planning, Law, Environmental Assessment L.L.B, University of Pennsylvania
PROJECT MANAGER:	McKinney, T.F., Senior Marine Geologist Geological Oceanography and Geochemistry Ph.D. Rensselaer Polytechnic Institute
SENIOR ADVISORS:	Palmer, H.D., Associate Marine Geology and Oceanography Ph.D. Geology, University of Southern California
	Scanland, T.B., Associate Marine Ecology Ph.D. Marine Biology, Scripps Institute of Oceanography
PRINCIPAL INVESTIGATORS:	Czlapinski, R.E., Project Engineer Site Selection Analysis and Methodology M.S. Ocean Engineering, Massachusetts Institute of Technology
	Ewald, J.L., Project Geologist Marine Geology B.S. Geology, Pennsylvania State University
	Hopkins, P., Staff Planner Economics M.S. Civil and Regional Planning, Ohio State University
	Nikituk, P.M., Staff Biologist Marine Biology B.S. Biology, Fairleigh Dickinson University
	Shen, D.G., Staff Engineer Physical Oceanography M.S. Civil and Environmental Engineering, Cornell University
	Fabian, A., Technical Editor B.A., Kings' College

REFERENCES

Alexander, J. and D'Agostino, A., 1972. Biological and chemical characteristics of sediments along the aquatic sections of the Dunwoodie-Glenwood interconnection. Final Report, Contract SR71-24, NYDSL, N.Y. 18 p.

Alexander, J.E. and Alexander E.C., March 1977. Chemical Properties MESA New York Bight Atlas Monograph 2, New York Sea Grant Institute, Albany, N.Y., 45 p.

Amos, A.F., July 1976. The New York Bight Hudson Canyon in October, 1974; Hydrography, Nephelometry, Bottom Photography, Currents, Vema Cruise 32, Leg. 1 Data under the direction of Lamont-Doherty Geological Observation for the U.S. Energy Research and Development Administration.

Anderlini, V.C., Chapman, J.W., Ginin, D.C., McCormick, S.J., Newton, A.S. and Risebrough, R.W., 1975. Heavy metal uptake study. Appendix H, pollutant uptake. In: Dredge Disposal Study, San Francisco Bay and Estuary. U.S. Army Engineer District, San Francisco, Ca.

Anderson, P.H. 1977. Delineation of Deciduous Wetlands Forests in Northeastern Connecticut-Master of Science Thesis, University of Connecticut, Storrs Inst. of Water Resources, 123 p.

Andreluinas, V.L. and Hard, C.G., 1972. Dredge Disposal; Real or Imaginary Dilemma Water Spectrum, 4; pp. 16-21.

Arbib, R. 1977. The Blue List for 1977. American Birds, 30(6) pp. 1031-1039.

Arthur, D. Little, Inc., 1974. The National Dredging Study, Multiple Volume Report Prepared Under Contract to the USACOE.

Barnard, W.D., August 1978. Prediction and Control of Dredged Material Dispersion Around Dredging and Open-Water Pipeline Disposal Operations. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Technical Report DS-78-13, p. 114.

Bartos, Jr., M.J., September 1977. Classification and Engineering Properties of Dredged Material. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Technical Report D-77-18, p. 170.

Basco, D.R., Dunlap, W.A. and Bouma, A.H., December 1974. Assessment of the Factors Controlling The Long-Term Fate of Dredged Material Deposited in Unconfined Subaqueous Disposal Areas. Texas A&M University, College Station, Texas. Contract Report D-74-8, p. 238.

Bastian, D.F., November 1974. Effects of Open-Water Disposal of Dredged Material on Bottom Topograpy Along Texas Gulf Coast. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., Miscellaneous Paper D-74-13, p. 34.

Bellan, G., et al., 1972. The Sublethal Effects of a Detergent on the Reproduction, Development and Settlement in the Polychaetous Annelid Capitella Capitata. Marine Biology 14:183.

Berriem, A., 1979. Connecticut Marine Trade Association, Milford, Connecticut, personal communication.

Bireley, L.E. and Buck, J.D., 1975. Microbiology of a former dredge spoil disposal area, Marine Pollution Bulletin 6:7, pp. 107-110.

Blom, B.E. et al., May 1976. Effect of Sediment Organic Matter on Migration of Various Chemical Constituents During Disposal of Dredged Material. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire. Contract Report D-76-7, p. 176.

Boesch, D.F., 1972. Species diversity of marine macrobenthos in the Virginia area Ches. Sci. 13:206-211.

Bokuniewicz, H.J. Gerbert, J., and Gordon, R.B. 1976. Sediment Mass Balance of a Large Estuary, Long Island Sound, Dept. of Geology and Geophysics, Yale University. Estuarine and Coastal Marine Science 4, pp. 523-536.

Bokuniewicz, H.J., and Gordon, R.B. 1973. Hardness of Nearshore Sediments, Long Island Sound (abst.). EOS, Trans. Amer. Geophys. Union, Vol. 54, No. 4 p. 335.

Bokuniewicz, H.J., and Gordon, R.B., 1977. Field Study of the Effects of Storms on the Stability and Fate of Dredged Material in Subaqueous Disposal Areas. U.S. Army, WES. Rep. No. D-77-22.

Bokuniewicz, H.J., and Gordon, R.B., 1977. Containment of Particulate Wastes At Open-Water Disposal Sites.

Bokuniewicz, H.J., et al. Environmental Consequences of Dredge Spoil Disposal in Long Island Sound, Phase II; Geophysical Studies Nov. 1973-Nov. 1974. Unpublished Report to U.S. Army Corps of Engineers. 37 p. SR-8

Bokuniewicz, H.J. et al., June 1976. Environmental Consequences of the Disposal of Dredged Material in Long Island Sound, Phase III; Geophysical Studies, April 1975-April 1976 Unpublished Report to U.S. Army Corps of Engineers, p. 95. SR-50.

Bokuniewicz, H. et al., September 1977. Aquatic Disposal Field Investigations, Eatons Neck Disposal Site, Long Island Sound; App. A: Investigation of the Hydraulic Regime and the Physical Characteristics of Bottom Sedimentation. Yale University, New Haven, Connecticut. Technical Report D-77-6, 195 p.

Bokuniewicz, H.J. et al., April 1978. Field Study of the Mechanics of the Placement of Dredged Material at Open-Water Disposal Sites. Volume I: U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, Vicksburg, Mississippi. Technical Report D-78-7, 318 p.

Bokuniewicz, H.J. et al., April 1978. Field Study of the Mechanics of the Placement of Dredged Material at Open-Water Disposal Sites. Volume II: Appendicies J-O. U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, Vicksburg, Miss., Technical Report D-78-7.

Bokuniewicz, H.J. and Gordon, R.B., 1978. Containment of Particulate Wastes at Open-Water Disposal Sites, Dept. of Geology and Geophysics, Yale University, New Haven, Connecticut.

Bonasis, J.J. 1975. Civil Engineering Considerations, In An Evaluation of Multi-Purpose Offshore Industrial Port Island Characteristics. Final Technical Report to NSF-RANN (Grant No. GI-43111).

Bowen, H.J.M., 1966. Trace Elements in Biochemistry. Academic Press; New York.

Bowley, C.J. and Barnes, J.C., January, 1974. Oceanographic Studies Using Satellite Data Detection of Near-Shore Phenomena. Task 11 Final Report for Environmental Prediction Research Facility Naval Post-Graduate School. 121 p.

Bowman, M.J. 1977. Nutrient Distributions and Transport in Long Island Sound Sea Grant Reprint Series Reprinted from Estuarine and Coastal Marine Science (1977) 553-548 NYSSGP-RR-78-01.

Bowman, M.J. and Weyl, P.K., August 1972. Hydrographic Study of the Shelf and Slope Waters of New York Bight. Technical Report No. 16, Marine Sciences Research Center, State Union of New York, Sunny Brook, New York.

Bowman, M.J. and Wunderlich, L.D., 1976. Distribution of Hydrographic Properties on the New York Bight Apex, In: Middle Atlantic Continental Shelf and The New York Bight Am. Soc. Liminol. Oceanogr. Spec. Symp. 2 pp. 58-67.

Bowman, M.J. and Wunderlich, L.D., February, 1977. Hydrographic Properties. MESA New York Bight Atlas Monograph 1, New York Sea Grant Institute, Albany, N.Y. 78 p.

Boyd et. al., 1972. Disposal of Dredge Spoil Problem Identification and Assessment and Research Program Development. U.S. Army Engineer Waterways Exp. Sta., Vicksburg, Miss., Tech. Rep. H-72-8, p. 121.

Bragg, D.M. and Schmidt, B.G., 1975. Market Demand and General Location Option In An Evaluation of Multi-Purpose Offshore Industrial Port Island Characteristics. Final Technical Report to NSF-RANN (Grand N2 GI-43111).

Brandsma, M.G. and Divoky, D.J., May 1976. Development of Models for Prediction of Short-Term Fate of Dredged Material Discharged in the Estuarine Environment. Tetra Tech, Incorporated, Pasadena, California. Contract Report D-76-5, p.290.

Brannon, J.M. et al., December, 1976. Selective Analytical Partitioning of Sediments to Evaluate Potential Mobility of Chemical Constituents During Dredging and Disposal Operations. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Technical Report D-76-7, p. 176

Brannon, J.M., August 1978. Evaluation of Dredged Material Pollution Potential. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Technical Report DS-78-6, p. 39.

Brannon, J.M., 1978. Evaluation of Dredged Material Pollution Potential, Tech. Rep. DS-78-6, Environmental Laboratory Work Unit 2D06.

Brannon, J.M., Engler, R.M., Rose, J.R., Hunt, P.G., and Smith, I., 1976a. Distribution of Toxic Heavy Metals in Marine and Freshwater Sediments. Proceedings Specialty Conference: Dredging and its Environmental Effects, American Society of Civil Engineers, pp. 455-495.

Brannon, J.M., Engler, R.M., Rose, J.R., Hunt, P.G., and Smith, I., 1976b. Investigation of Partitioning of Various Elements in Dredged Material U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., Technical Report, pp. 76-77.

Brehmer, M.L., 1967. A Study of the Effects of Dredging and Dredge Spoil Disposal at the Marine Environment. Special Scientific Report No. 8, VIMS; Gloucester Point, Va.

Broughton, J.D., May 1977. Investigation of Subaqueous Borrow Pits as Potential Sites for Dredged Material Disposal. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss., Technical Report D-77-5, p. 1909.

Brown, C.L., 1975. A Compilation of Progress Reports: Environmental Monitoring Program, Phase II, Dredging and Dumping of Spoils, Thames River, New London, Connecticut. May-December, 1978. Naval Underwater Systems Center, Ocean Technology Division, New London Laboratory, New London, Connecticut.

Buelow, R.W., 1968. Ocean Disposal of Waste Material, In: Transactions of the National Symposium on Ocean Sciences & Engineering of the Atlantic Shelf. Delaware Valley Section Marine Technology Society, March 19-20 Phila., Pa. pp. 311-337.

Bureau of Land Management, 1977. Final Environmental Impact Statement, Proposed 1976 OCS Oil and Gas Lease Sale No. 40 Offshore the Mid-Atlantic States. 4 Volumes.

Bureau of Land Management, 1977. Final Environmental Statement, Proposed 1977 Outer Continental Shelf Oil and Gas Lease Sale No. 42, Offshore the North Atlantic States, 5 Volumes.

Bureau of Land Management, 1978. Final Environmental Impact Statement, Proposed 1979 OCS Oil and Gas Lease Sale No. 49, Offshore the Mid-Atlantic States. 3 Volumes.

Burks, S.A., and Engler, R.M., August 1978. Water Quality Impacts of Aquatic Dredged Material Disposal (Laboratory Investigations) Technical Report DS-78-4. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Butman, B. and Noble, M., 1978. Bottom Sediment Mobility in the Offshore Middle Atlantic Bight 1976-1977. In: USGS, 1978. Geological Studies of the Middle Atlantic Outer Continental Shelf, Final Report, October 1, 1976-September 30, 1977. Chapter 2.

Butman, B., Noble, M., and Folger, D., 1977. Long Term Observations of Bottom Current and Bottom Sediment Movement on the Middle Atlantic Continental Shelf., In: VIMS, 1977. Middle Atlantic OCS Environmental Studies, Vol. 3., Geologic Studies.

Cable, C.C., January 1969. Optimum Dredging and Disposal Practices in Estuaries. Journal, Hydraulics Div; American Society of Civil Engineers, Wash., D.C., Vol. 9S, No. HY-1, pp. 103-114.

Caplan, Ronald I. Dredged Material Research Program, Aquatic Disposal Field Investigations Eatons Neck Disposal Site, Long Island Sound. Appendix E: Predisposal Baseline Conditions of Zooplankton Assemblages, Technical Report D-77-6 U.S. Army Engineer Waterways Experiment Station, New York Ocean Science Laboratory.

Carey, A.G., Jr., 1967. Energetics of the Benthon of Long Island Sound 1. Oxygen Utilization of Sediments. Bull. Bingham Oceanog. Collect. 19; pp. 136-144.

Carlo, E.G., January 1978. Recreation. MESA New York Bight Atlas Monograph 19. New York Sea Grant Institute, Albany, N.Y. 32 p.

Carmody, D.J., Pearce, J.B., and Yasso, W.B., 1973. Trace Metals in Sediments of the New York Bight: Marine Pollution Bulletin Volume 4 (9), pp. 132-135.

Charnell, R.L., Hansen, D.V., August 1974. Summary & Analysis of Physical Oceanography Data Collected in The New York Bight Apex During 1969-70, MESA Report No. 74-3, Boulder, Colorado, p. 44.

Charnell, R.L. and Mayer, D.A., 1975. Water Movement Within the Apex of the New York Bight during Summer & Fall of 1973. In: Tech. Mem. ERL MESA 3 NOAA, p. 11.

Chen, K.Y., Lu, J.C.S., and Sycip, A.Z., 1976. Mobility of Trace Metals During Open Water Disposal of Dredged Material and Following Sedimentation. Proceedings Specialty Conference: Dredging and its Environmental Effects, American Society of Civil Engineers, pp. 435-454.

Chen, K.Y. et al., February 1976. Research Study on the Effect of Dispersion Settling, and Resedimentation on Migration of Chemical Constituents During Open-Water Disposal of Dredged Materials. Environmental Engineering Program, Los Angeles, Calif. Contract Report D-76-1, pp. 243.

Chrang, Erick, 1974. Masters Thesis, The Implication of Sediment Dynamics and Heavy Metal Dispersion to Ocean Disposal at the "NB" Buoy, South of Fire Island, New York, Adelphi University.

Clark, John, 1968. Seasonal Movements of Striped Bass Contingents of Long Island Sound and the New York Bight. Trans. Amer. Fish Soc. 97 (4) pp. 320-343.

Clark, J. et al., August 1969. Technical Papers of The Bureau of Sport Fisheries and Wildlife No. 28. Studies of Estuarine Dependence of Atlantic Coastal Fishes. U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Washington, D.C., p. 132.

Cobb, S.P. et al., 1978. An Environmental Inventory, U.S. Army Engineer Waterways, Experiment Station, Vicksburg, Mississippi. NTIS No. AD A 055 217.

Cocoros, G., Cahan, P.M. and Siler, W., 1973. Mercury Concentrations in Fish, Plankton and Water From Three Western Atlantic Estuaries. J. Fish. Biology (5), pp. 641-647.

Cohen P., Franke, O.L., and Foxworthy B.L., 1968. An Atlas of Long Island's Water Resources. New York Water Resources Commission Bill 62, State of New York.

Cok, A.E. and McKinney, T.F., September 1973. MESA: Interdisciplinary Approach to Environmental Analysis of Continental Margins. Marine Sediments, Vol. 9, No. 2, pp. 37-44.

Cok, A.E. and Siskin, L.A., 1971. Investigation of Surface and Subsurface Sedimentary Deposits in Offshore Environments of Southern Long Island. Prepared for the Nassau-Suffolk Regional Marine Resources Council, Nassau-Suffolk Regional Planning Board.

College of Marine Studies, University of Delaware, May 1975. An Evaluation of Multi-Purpose Offshore Industrial Port Islands, General Island Characteristics. Final Technical Report to NSF-RANN (Grant No. GI-43111).

Colony, R.J., 1932. Source of the Sands of the South Shore of Long Island and the Coast of New Jersey. J. Sediment. Pelrog., Vol. 2, pp. 150-159.

Connecticut Dept of Environmental Protection, N.Y. Dept. of Environmental Construction, April, 1977. Interim Plan For The Disposal of Dredged Materials in Long Island Sound.

Connecticut DEP, 1979. Logbook Statistics Fishery Data 1/1/78 through 12/31/78 unpublished data.

Connecticut University-Institute of Water Resources, 1973. Proceedings: First Wetlands Conference held on June 20, 1973 at Stoors, Connecticut, Helfgott, T., Lefor M., Kennard, W.C.: Edition, p. 199.

Conner, W.G. et al., 1979. Disposal of Dredged Material Within the New York District: *Volume 1 Present Practices and Candidate Alternatives.* MITRE Technical Report MTR-7808. MITRE Corporation, McLean, Virginia prepared for U.S. Army Corps of Engineers, New York District.

Conover, S., 1956. Oceanography of Long Island Sound, 1952-1954. IV. Phytoplankton. Bull. Bingham. Oceanogr. Coll. 15:62-112.

Cotton, J.B., Stoddard R.R., June 1973. Bottom-water Temperature on the Continental Shelf, Nova Section to New Jersey, NOAA Technical Report NMFS CIRC-376,p. 55

Creager, J.S., and Sternberg, R.W., 1972. Some Specific Problems in Understanding Bottom Sediment Dispersal and Distribution on The Continental Shelf. In: Swift D.J.P., Duane D.B., and Pilkey, O.H. (Editors), Dowden, Hutchinson and Ross, Stroudsburg, Pa., pp. 347-367.

Cronin, L.F. et al., 1967. Interim report on gross physical and biological effects of overboard spoil disposal. Ref. No. 67-34, Chesapeake Bay Biology Laboratories.

D'Agostino, A., and Colgate, W.A., 1973. Infaunal invertebrates in the near shore waters of Long Island Sound. Benthos of Northport. Final Report Contract SR72-22 with Long Island Lighting Company. 28 p.

Dames & Moore, February 1976. Draft Environmental Impact Statement on the Ocean Dumping of Sewage Sludge in the New York Bight. Prepared for USEPA Region II, New York 341 p.

Dames & Moore and McClelland Engineers, Inc. January, 1977. Preliminary Geologic and Geotechnical Engineering Studies, North Atlantic Outer Continental Shelf.

Dames & Moore, 1979. Delphi Session Workbook, July 11, 12 and 13, 1979. Site Selection Study For Open Water Disposal of Dredged Materials, Long Island Sound, Block Island Sound and Adjacent Open Waters. New England Division, Corps of Engineers, Waltham, Mass.

Deevey, G.B., 1952a. A survey of the zooplankton of Block Island Sound, 1943-1946. Bull. Bingham. Oceanogr. Coll., 13(3):65-119.

Deevey, G.B., 1952b. Quantity and composition of the zooplankton of Block Island Sound, 1949. Bull. Bingham. Oceanogr. Coll., 13(3):120-164.

Dehlinger, Peter et al., 1974. Investigations on Concentrations, Distributions, and Fates of Heavy Metal Wastes in Parts of Long Island Sound. Final Report submitted to Office of Sea Grant Programs NOAA by the University of Conn. Marine Science Institute.

Delaware Sea Grant Program, June 1977. Report of the Atlantic Offshore Users Workshop, May 19-21, 1977, Clayton Conferences Center, Newark, Del.

Dennis, D.S., 1975. Polychlorinated Biphenyls in the Surface Waters and Bottom Sediments of the Major Drainage Basins of the United States. Proceedings of National Conference on Polychlorinated Biphenyls, November 19-21, 1975, Chicago, Ill. Published by EPA, Office of Toxic Substances, Washington, D.C., 183 p.

DHEW, 1972. PCBs and the Environment. NTIS COM-72-10419, 181 p.

DiSalvo, L.H., et al., 1977. Assessment and Significance of Sediment-Associated Oil and Grease in Aquatic Environments. Dredged Material Research Program Technical Report D-77-26 Environmental Effects Laboratory, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Dowd, R.M., February, 1972. Dredging on Long Island, prepared by the Center for the Environment and Man, Inc. for Marine Resource Council, Nassau-Suffolk Regional Planning Board, 43p.

Drake, D.E., 1974. Suspended Particulate Matter in the New York Bight Apex: September-November 1973, NOAA Technical Report ERL 318-MESA, 153p.

Drake, D.E., 1976. Suspended Sediment Transport and Mud Deposition on Continental Shelves. In: Marine Sediment Transport and Environmental Management Chapt. 9 p. 127-158, John Wiley & Sons.

Duane, B.D., 1968. Sand Deposits on the Continental Shelf: A Presently Exploitable Resource, In: Transactions of the National Symposium on Ocean Sciences and Engineering of the Atlantic Shelf. Delaware Valley Section, Marine Technology Society, March 19-20, Philadelphia, Pa.

Duane, David B., 1969. Sand Inventory Program-A Study of New Jersey and Northern New England Coastal Waters. Journal of The American Shore and Beach Preservation Association, Vol. 37, November 2, pp. 12-16.

Duane, D.B., Field, M.E., Meisburger, E.P. et al., 1972. Linear Shoals on the Atlantic Inner Continental Shelf, Florida to Long Island. In: Shelf Sediment Transport: Process and Pattern (Swift, D.J.P., Duane, D.B., and Pilkey, O.H., Editors,) Dowden, Hutchinson and Ross, Straudsburg, Pa. Chapter 22, pp. 447-478.

Duce, R.A. Parker, P.L., and Gram, C.S., 1974. Pollutant Transfer to the Marine Environmental; Deliberations and Recommendations of the NSF/IDOE. Pollutant Transfer, Workshop held in Port Arausos, Texas Jan. 11-12, 1974. Published in Kingston, R.I., 55p.

Duke, T.W., et al., 1970. A Polychlorinated Biphenyl (Aroclor 1954) in the Water, Sediment and Biota of Escambia Bay, Florida. Bulletin, Environ. Contam. Toxicol. 5: 171.

Ehrlich, A., August 1954. Subsurface Density Inversions off Nantucket Island. Transactions American Geophysical Union Vol. 35, No. 4., pp. 573-584.

Elder, D.L., and Fowler, S., 1977. PCBs in the Deep Ocean, Sea Technology, p. 24.

Emery, K.O., 1977. Atlantic Continental Shelf and Slope of The United States, Geologic Background. Geological Survey Professional Paper 529-A., p. 23

Emery K.O., Merrill, A.S., Trumbull, J.V.A., January 1965. Geology and Biology of the Sea Floor as Deduced from Simultaneous Photographs and Samples. Limnology and Oceanography, Vol. 10, No.1. p.-211

Emery, K.O., and Milliman, J.D., 1970. Quaternary Sediments of the Atlantic Continental Shelf of the United States. Quaternaria, Vol. 12, pp.3-18.

Emery, K.O., and Uchupi, E., 1972. Western North Atlantic Ocean: Topography, Rocks, Structure, Water, Life, and Sediments. Memoir 17, AAPG, Tulsa, Okla., 532p.

Emery, K.O., Wigley, R.L., and Rubin M., 1965. A Submerged Peat Deposit off the Atlantic Coast of the United States, Limnology and Oceanography, Supplement, Volume 10, pp. 97-102.

Energy Resources Co. Inc. 1978. Ecological Evaluation of Proposed Oceanic Discharge of Dredged Material From Shaw Cove, New London, Conn. Prepared for New England Corps of Engineers, Department of the Army, Waltham, Mass.

Energy Resources Company Inc. "Reconnaissance Report: Dredged Material Containment in Long Island Sound" January 1979, done for the U.S. Army Corps of Engineers, New England Division.

Engineering Science Inc., 1977. An evaluation of Oil and Grease Contamination Associated With Dredged Material Containment Areas. U.S. Army Engineers Waterways Experiment Station, Dredged Material Research Program, Work Unit No. 6B05 Vicksburg, Miss.

Environmental Science Services Administration-Coast and Geodata Survey and Fish and Wildlife Service-Bureau of Commercial Fisheries, 1967. Long Island Sound Chart No. 0808N-53 Bathymetry. Chart No. 0808N-51 Scale 1:125,000 Chart No. 0808N-54 Chart No. 0808N-52.

Estes, E.L. and Scrudato, R.J., December 1977. Aquatic Disposal Field Investigations, Galveston, Texas, Offshore Disposal Site; Appendix A: Investigation of the Hydraulic Regime and Physical Nature of Sedimentation. Texas A&M University, College Station, Texas. Technical Report D-77-20, p. 155.

Ewing, M., Worzel, J.L., Steinland, N.C. and Press, F., September 1950. Geophysical Investigations in the Emerged and Submerged Atlantic Coastal Plain; Part V: Woods Hole, N.Y., and Cape May, Sections. Geol. Soc. of Amer. Bull. Vol. 61, pp. 877-892.

Federal Register, January 1979. List of Endangered and Threatened Wildlife and Plants. U.S. Department of Interior, Fish and Wildlife Service, Volume 44, No. 12.

Feldhausen, P.H. and Ali, S.A., 1976. Multivariate Statistical Environmental Analysis of Living Benthnic Foraminiferia in Long Island Sound.

Feldhausen, P.H. and Ali, S.A., 1976. Sedimentary Environmental Analysis of Long Island Sound USA with Multivariate Statistics, In: D.F. Merriam, ed., Quantitative techniques for the analysis of Sediments, Pergamon Press, New York, pp. 73-98.

Fisher, J.B. and McCall, P.L., 1973. The Effect of Environmental Perturbations on Benthic Communities: A Experiment in Benthic Recolonization and Succession in Long Island Sound. Report #4 Unpublished Report to U.S. Army Corps of Engineers.

Fisher, N.S. and Wurster, C.F., 1973. Individual and Combined Effects of Temperature and Polychlorinated Biphenyls on the Growth of Three Species of Phytoplankton. Environ. Pollut. 5: 205.

Fisher, N.S., et al., 1974. Effects of PCB on Interspecific Competition in Natural and Gnotobiotic Phytoplankton Communities in Continuous and Batch Cultures. Microbial Ecol. 1: 39.

Fitzgerald, W.F., Hunt, C.D., Lyons, W.B., and Szechtman, R.J., 1973. Budgets of Heavy Metal Wastes in Eastern Long Island Sound: Chemical Investigations; In: A Determination of Heavy Metal Wastes in Long Island Sound, First Annual Sea Grant Report, University of Connecticut.

Folger, D.W., 1977. Submersible Observations of the Bottom In and Near Petroleum Lease Areas off the Middle Atlantic States. In: VIMS, 1977, Middle Atlantic Outer Continental Shelf Environmental Studies, Vol 3, Geologic Studies.

Food and Agriculture Organization of the U.N., 1977. Report of the ACMRR/IABO Working Party on Biological Effects of Pollutants and Report of the ACMRR/IABO Expert Consultation on Bioassays with Aquatic Organisms in Relation to Pollution Problems. FAO Fisheries Report No. 187., 28p.

Freeland G.L. Surficial Sediments of the New York Bight NOAA-Atlantic Oceanographic and Meteorological Laboratories, Miami, Fla., 157p. (unpublished manuscript)

Freeland, G.L. and Merrill, G.F., 1976. Deposition and Erosion in the Dredge Spoil and other New York Bight Dumping Areas. Proc. Amer. Society of Civil Engineers Specialty Conference on Dredging and Its Environmental Effects, Mobile, Al. Jan. 26-28, pp. 936-946.

Freeland G.L. and Swift, D.J.P, 1975. New York Alternative Dumpsite Assessment-Reconnaissance Study of Surficial Sediments. Seventh Annual Offshore Technology Conference, Houston, Texas.

Freeland, G.L., Swift, D.J.P, and Stubblefield W.L., 1972. Surficial Sediments of NOAA-MESA Study Areas in the New York Bight. Mid-Atlantic Shelf/New York Bight ASLU Symposium, pp. 24-25.

Freeland, G.L., Swift, D.J.P., Stubblefield, W.L., and Cok, A.E., 1976. Surficial Sediments of the NOAA-MESA Study Area in the New York Bight, In: Middle Atlantic Continental Shelf and New York Bight, Am. Soc. Limnol. Oceanog. Spec. Symp., Vol. 2, pp. 90-101.

Freeman, B.L. and Walford L.A., 1974. Anglers Guide to the United States Atlantic Coast, Section II: Fish, Fishing Grounds & Fishing Facilities. 16 p.

Friedman, G.M., 1966. Study of Continental Shelf and Slope on the Coast of Long Island, N.Y., and New Jersey. Maritime Sediments, Vol. 2, pp. 21-22.

Friedman, G.M., and Sanders, J.E., April 1970. Integrated Continental-Shelf and Marginal Marine Environmental Research Program: Sediments, Organisms, and Waters in New York Bight and Vicinity. Maritime Sediments, Vol. 6, No. 1, pp. 26-29.

Fulk, R., Gruber, D., and Wullschleger, R., December 1975. Laboratory Study of the Release of Pesticide and PCB Materials to the Water Column During Dredging and Disposal Operations. Envirex, Inc., Milwaukee, Wisc., Contract Report D-75-6, p. 112.

Gadd, P.E., Lavelle, J.W., and Swift, D.J.P., 1975. Calculations of Sand Transport on the New York Shelf Using Near-Bottom Current Meter Observations. American Geophyical Union, Fall Annual Meeting 56, No. 12, p. 1003.

Gambrell, R.P., Khalid, R.A., and Patrick, W.H., Jr., 1976. Physiochemical Parameters that Regulate Mobilization and Immobilization of Toxic Heavy Metals. Proceedings Specialty Conference: Dredging and its Environmental Effects, American Society of Civil Engineers, pp. 418-434.

Gambrell, R.P., Khalid, R.A., Patrick, W.H., Jr., 1978. Disposal Alternatives for Contaminated Dredged Material as a Management Tool to Minimize Adverse Environmental Effects, Dredged Material Research Program Technical Report DS-78-8, Chief of Engineers, U.S. Army, Washington, D.C.

Gambrell, R.P. et al., May 1977. Transformations of Heavy Metals and Plant Nutrients in Dredged Sediments as Affected by Oxidation Reduction Potential and pH; Volume II, Materials and Methods/Results and Discussion. Louisiana Agricultural Experiment Station, Baton Rouge, La. Contract Report D-77-4, p. 336.

Garrison L.E., and McMaster, R.L., 1966. Sediments and Geomorphology of the Continental Shelf Off Southern New England. Marine Geology, Vol. 4, pp. 273-289.

Garrison, L.E., 1970. Development of Continental Shelf South of New England. AAPG Bull. Vol. 54 No. 1, pp. 109-124.

Garvine, R.W., 1975. The Distribution of Salinity and Temperature in the Connecticut River Estuary. Journal of Geophysical Research, Vol. 80, No. 9., pp. 1176-1183.

Gevirtz, J.L., Park, R. A. and Friedman, G.M., March 1971. Paraecology of Benthonic Forminifera and Associated Micro-Organisms of the Contenental Shelf off Long Island, New York, Journal of Paleontology Vol. 45, No.2; pp. 153-177.

Gibbs, R.J., 1973. Mechanisms of Trace Metal Transport in Rivers, Science, Volume 180, pp. 71-73.

Gordon, A.L., Amos, A.F. and Gerard, R.D., October 1974. New York Bight Water Stratification. Am. Soc. Limnol. Oceanogr. pp. 45-57 Spec. Symp. 2. Lamont-Doherty Geological Observatory of Columbia University, Palisades, N.Y.

Gordon, R.B., December 1973. Dispersion of Dredge Spoil Dumped in a Tidal Stream: Observations at the New Haven Dump Site, unpublished report to U.S. Army Corps of Engineers, p.11 SR-19

Gordon, R.B., Rhoads, D.C., and Turekian, K.K., 1972. The Environmental Consequences of Dredge Spoil Disposal in Central Long Island Sound: I. The New Haven Spoil Ground and New Haven Harbor. Report to U.S. Army Corps of Engineers. Mimeo rept. Dept. of Geology and Geophysics, Yale University.

Gordon, R.B. and Pilbeam, C., 1973. Tides and Currents in Long Island and Block Island Sound (Abst.), EOS, Trans. Amer. Geophy. Union, Vol. 54, No. 4, p.301.

Gordon, R.B. and Pilbeam,C., January 1975. Circulation in Central Long Island Sound Journal of Geophysical Research, Vol. 80, No. 3, pp. 414-422.

Gorsline, D.S., 1977. Sediment Dynamics and Solid Waste Disposal, Dept. of Geological Sciences, U. of Southern California, Los Angeles, Ca.

Grant, M.J., 1973. Rhode Island's Sands: Management Guidelines for Sand and Gravel Extraction in State Waters. Marine Tech. Rep. No. 10. Kingston, R.I: Univ. of Rhode Island.

Green, J., 1963. A Biology of Crustacea, Quandrangle Books, Chicago, Illinois, 180 p.

Gross, M.G., 1972. Geologic Aspects of Waste Solids and Marine Waste Deposits, New York Metropolitan Region. Geol. Soc. Amer. Bull. 3, pp. 3163-76.

Gross, M.G., 1975. Sediment and Waste Deposition in New York Harbor, Annals New York Academy of Sciences - Marine Sciences Research Center, SUNY Stony Brook, pp. 112-128.

Gross, M.G., July 1976. Waste Disposal, MESA New York Bight Atlas Monograph 26 New York Sea Grant Institute, Albany, New York.

Gross, M.G. (Editor), 1976. Middle Atlantic Continental Shelf and the New York Bight, Special Symposium, Vol. 2, Amer. Society of Limnology and Oceanography, Inc. 441p.

Gross, M.G., Black, J.A. et al., April 1971. Survey of Marine Waste Deposits, New York Metropolitan Region, Technical Report No. 8, Marine Sciences Research Center, Stony Brook, N.Y.

Gross, M.G., and Palmer, H.D., 1979. Waste Disposal and Dredging Activities; The Geological Perspective. In: Palmer,H.D., and Gross, M.G.(eds) Ocean Dumping and Marine Pollution, Hutchinson & Ross, Stroudsburg, Pa.

Grosslein, M.D., 1976. Some Results of Fish Surveys in the Mid-Atlantic Important for Assessing Environmental Impacts In Middle Atlantic Continental Shelf and New York Bight. Amer. Soc., Limnol. Oceanog. Spec. Symp., Vol. 2, pp. 312-328.

Gustafson, J.F., 1972. Beneficial Effects of Dredging Turbidity, World Dredging and Marine Construction, Volume 8, pp. 14-15.

Hansen, D.J., 1974. Aroclor (R) 1254: Effect On Composition of Developing Estuarine Animal Communities in the Laboratory. Contributions Marine Sciences 18:19.

Hansen, D.J., 1976. PCB's Effects on and Accumulation by Estuarine Organisms. Proc. Nat. Conf. on Polychlorinated Biphenyls, p. 259.

Hard, C.G., and Palmer, H.D., 1976. Sedimentation and Ocean Engineering: Ocean Dumping, In: Stanley, D.J. and Swift, D.J.P. (Editors) Marine Sediment transport and Environmental Management, pp. 557-577.

Hardy, C.D., 1971. Movement and Quality of Long Island Sound Waters. Technical Report No. 17, November, 1972, Marine Sciences Research Center, St. U. of N.Y., Stony Brook. 68 p.

Hardy, C.D., January, 1972. Hydrographic Data Report: Long Island Sound - 1970 Part II. Marine Sciences Research Center St. U. of N.Y., Stony Brook, NY Technical Report No. 13.

Hardy, C.D., Baylor E.R., Moskowitz, P., Jan. 31, 1975. Sea Surface Circulation in the Northwest Apex of the New York Bight with Appendix: Bottom Drift Over the Continental Shelf of the New York Bight., Part I & Part II, MSRC, SUNY Stony Brook, 145 p. (Part I).

Harrald, J., 1980. U.S. Coast Guard Captain of the Port, New Haven. Personal Communication.

Harris, E., 1959. The Nitrogen Cycle In Long Island Sound. Bulletin, Bingham Oceanographic College, 17 (1):31-65.

Harris, W.H., 1976. Spatial and Temporal Variation in Sedimentary Grain-Size Facies and Sediment Heavy Metal Ratios in the New York Bight Apex, American Society of Limnology Oceanography, Special Symposium, Volume 2, pp. 102-123.

Harvey, G.R, Miklas, H.P., Bowen, V.T. and Steinhauer, W.G., 1974. Observations on the Distribution of Chlorinated Hydrocarbons in Atlantic Ocean Organisms, J. Mar. Research 32, 103-118.

Haskett, Sarah, 1975. Evaluating Visual Quality of the Coastline: Some Significant Issues. New York Sea Grant Project - Visual Quality of the Coastal Zone. p. 21.

Hathaway, C., and Weed, E.G.A., (Editors), 1976. Preliminary Summary of the 1976 Atlantic Margin Coring Project of the U.S. Geological Survey. USGS Open File Report 76-844, 215+ p.

Hathouny, J.C., 1971 (Unpublished). Continental Margin Program; Atlantic Coast of the United States; Sample Collection and Analytical Data: Vol. 2, USGS Open File Data, Woods Hole Oceanographic Institute Technical Report 71-115.

Hawe, M.A., Clapp R.B. and Weske, J.S., Sept. 1978. Marine and Coastal Birds. MESA New York Bight Atlas Monograph 31, New York Sea Grant Institute, Albany, New York 87p.

Hazelworth, J.B., Kolitz, B.L., Starr, R.B. et al., July 1974. New York Bight Project, Water Column Sampling Cruises #1-5, NOAA Ship Ferrel, August-November 1973, MESA Report # 74-2, 191 p.

Hennemuth, R.C., 1975. Fisheries and Renewable Resources of the Northwest Atlantic Shelf, In Effects of Energy Related Activity on the Atlantic Continental Shelf. Conference at Brookhaven National Laboratory, Nov. 10-12, 1975, Upton, N.Y., pp. 146-166.

Hillman, R.E., June 1971. Effects of Dredging on Maine Ecology, Condensed from a paper presented at The World Dredging Association Seminar, Los Angeles, Ca., Feb. 1971 pp. 25-27.

Hirsch, N.D., DiSalvo, L.H. and Peddicord, R., August 1978. Effects of Dredging and Disposal on Aquatic Organisms. Naval Biosciences Laboratory, Oakland, California Technical Report DS-78-5, p. 41.

Hjulstrom, F., 1935. Studies of the Morphological Activity of Rivers as Illustrated by the River Fyris. Bull. Geol. Inst. Uppsala, 25. pp. 221-527.

Holliday, B.W., August 1978. Processes Affecting the Fate of Dredged Material. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Technical Report DS-78-2, p. 32.

Holliday, B.W. et al., Dec. 1978. Predicting and Monitoring Dredged Material Movement Environmental Laboratory and Hydraulics Laboratory U.S. Army Engineer Waterways Experiment Station.

Horne, R.A., Mahler, A.J., and Rosello, R.C., 1971. The Marine Disposal of Sewage Sludge and Dredge Spoil in the Waters of the New York Bight. U.S. Army Corps of Engineers, Rep. Coastal Eng. Res. Center, Tech. Memo 1-71.

Hornberger, G.M. and Kelly,M.G., November 1975. Methods of Dissolved Oxygen Budget Analysis for Assessing Effects of Dredged Material Disposal on Biological Community Metabolism. University of Virginia, Charlottesville, Va. Contract Report D-75-3, p. 84.

Huston, J., August 1967. Dredging Fundamentals. J. of the Waterways and Harbors Division, Proceedings of the American Society of Civil Engineers pp. 45-68.

Huston, J.W., and Huston, W.C. "Techniques for Reducing Turbidity During Dredging Operations," May 1976. Prepared by John Huston, Inc. under contract to the U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. NTIS No. AD A026 623. Contract Report D-76-4, p. 99.

Inman, D.L., 1963. In "Submarine Geology", (F.P. Shepard, ed.) Chap. V. 2nd Ed., Harper & Row, New York.

Interstate Electronics Corp. (Oceanics Division), September 6, 1972. Phase B, Case Study Report - New York Bight, Prepared for the U.S. EPA, Applied Technology Division, Contract 68-01-0160, Report 445 - B1.

Interstate Electronics Corp. (Oceanics Division), Sept. 8, 1972. Summary of Case Study Findings. Prepared for U.S. EPA, Applied Technology Division, Contract 68-01-0160.

Interstate Electronics Corporation (Oceanics Division), Dec. 6, 1972. A National Overview of Existing Water Quality Monitoring, Report 445-A, prepared for U.S. EPA, Water Quality Protection Branch - Contract 68-01-0160.

Interstate Electronics Corporation (IEC) - Oceanics, May 1973. Bibliography on Ocean Waste Disposal. Report 4460C1542 for USEPA Ocean Disposal Program Office.

Interstate Electronics Corporation (IEC) - Oceanics, June 1973. Directory of Managers, Engineers and Scientists in Ocean Waste Disposal and Related Environmental Science Fields for USEPA, Ocean Disposal Program Office. IEC Report 4460C1543.

JBF Scientific Corp. July 1978. An Analysis of the Functional Capabilities and Performance of Silt Curtains. WES Technical Report D-78-39 prepared for the Environmental Laboratory (Work Unit 6C06).

JBF Scientific Corp. 1978. Draft Final Report - Results of Bioassays for Norwalk Harbor - Submitted to Materials Testing Laboratory New England Division Corps of Engineers., Waltham, Mass.

Johanson, E.E., Bowen, S.P. and Henry, G., April 1976. State-of-the-Art Survey and Evaluation of Open - Water Dredged Material Placement Methodology. J.B.F. Scientific Corporation, Burlington, Mass. Contract Report D-76-3, p. 192.

Johnson, B.H., March 1974. Investigation of Mathematical Models for the Physical Fate Prediction of Dredged Material. U.S. Army Engineer Waterways Experiment Station, Vicksbury, Miss. Technical Report D-74-1, p. 70.

Johnson, B.H., and Holliday, B.W., August 1978. Evaluation and Calibration of the Tetra Tech. Dredged Material Disposal Models Based on Field Data. WES Technical Report D-78-47, prepared by the Hydraulics Laboratory and Environmental Laboratory (Work Unit 1 BO6 and 1 BO7).

Kamlet, K.S., 1978. Constraints on the Offshore Disposal of Dredged Material, Paper presented at Dredging Seminar Sponsored by Jacksonville District COE and State of Florida, Miami Beach, July 9-12, 1978.

Kaplan, E.H. et al., 1975. Some Factors Affecting the Colonization of Dredged Channel, Marine Biology 32, 193-204 by Springer-Verlag.

Kendall, A.W. Jr., 1975. Patterns of Larval Fish Distribution in the Middle Atlantic Bight, In: Effects of Energy-Related Activities on the Atlantic Continental Shelf. Conference at Brookhaven National Laboratory, Nov. 10-12, 1975, Upton, N.Y., pp. 126-145.

Ketchum, B.H. and Corwin,N., October, 1964. The Persistence of "Winter" Water on the Continental Shelf South of Long Island, New York. Limnology and Oceanography, Vol. IX, No. 4, pp. 467-475.

Khalid, R.A. et al., May 1977. Transformations of Heavy Metals and Plant Nutrients in Dredged Sediments as Affected by Oxidation Reduction Potential and pH; Volume 1, Literature Review. Louisiana Argricultural Experiment Station, Baton Rouge, La. Contract Report D-77-4, p. 238.

Knauer, G.A. and Martin, J.H., 1977. Mercury in a Marine Pelagic Food Chain. Limnology and Oceanography 17, pp. 868-876.

Koppelman, L.E., Weyl, P.K., Gross, Grant, M. and Davies, D.S., 1976. The Urban Sea: Long Island Sound. New York Praeger Special Studies Program. 223 p.

Kranz, P.M., 1972. The Anastrophic Burial of Bivalves and Its Paleoecological Significance. Ph.D. Dissertation, University of Chicago, 177 p.

Krauskopf, K.B., 1956. Factors Controlling the Concentrations of Thirteen Rare Metals in Sea Water. Georhim. Cosmochim. Acta, Volume 9, pp. 1-32.

Krenkel, P.A., Harrison J., and Burdick J.C. III, (Editors), January 26-28, 1976. Proceedings of the Specialty Conference on Dredging and the Environmental Effects. ASCG Alabama Section and Task Committee on Dredging and its Environmental Effects of the Committee on Sedimentation of the ASCE Hydraulics Division.

Krishnappan, B.G., 1975. Desposition of Granular Material Dumped in Deep Water., Scientific Series No. 55, Environment Canada - Centre for Inland Waters, Burlington, Ontario, 41 p.

Krizck, R.J., Gallagher, B.J. and Karadi, 1976. Water Quality Effects of a Dredging .Disposal Area. Prec. An. Svc. Civ. Eng. J. Env. Eng. Div. 102 (EE2) pp.389-409.

Krotee R. and Krotee W., 1965. Shipwreckers Off the New Jersey Coast. Middle Atlantic Underwater Council, Underwater Society of America, Philadelphia, Pa.

Laevasto, T., Callaway R. et al., January 1974. Environmental Prediction Research Facility. Computation of Tides, Currents and Disposal of Pollutants in New York Bight from Block Island to Atlantic City with Large Grid Size, Single and Two-Layer Hydrodynamic - Numerical Models. Part 4. NTIS U.S. Dept. of Commerce AD-778 617.

Laevasto, T., Clancy, M. and Stroud, A., January 1974. Environmental Prediction Research Facility. Computation of Tides, Currents and Dispersal of Pollutants in Lower Bay and Approaches to New York with Fine and Medium Grid Size Hydrodynamical Models. Part 3 NTIS U.S. Dept. of Commerce AD-778 610.

Lauff, G.H., 1967. Estuaries. American Association for the Advancement of Science Washington D.C. Publication No. 83 757p.

Lavelle, J.W., Gadd, P.E., Ham, G.C. et al., 1976. Preliminary Results of Coincident Current Meter and Sediment Transfer Observations for Wintertime Conditions on the Long Island Inner Shelf. Geophysical Research Letters, Vol. 3, No. 2, pp. 97-100.

Leathem, W., Kinner, P., Maurer, D., Biggs, R. and Treasure, W., 1973. Effect of Spoil Disposal on Benthic Invertebrates. Mar. Pollut. Bull. 4(8), pp. 122-125.

Leatherland, T.M., Burton, J.D., McCartney, M.J. and Morris, R.J., 1973. Concentrations of Some Trace Metals in Pelagic Organisms and of Mercury in North Atlantic Ocean Water. Deep Sea Research 20, pp. 679-685.

Lee, G.F. and Plumb, R.H., June 1974. Literature Review on Research Study for the Development of Dredged Material Disposal Criteria. Institute of Environmental Studies, Dallas, Texas. Contract Report D-74-1, p. 163.

Lee, G.F., et al., 1975. Research Study for the Development of Dredge Disposal Criteria. Dredged Material Research Program Contact Rep. D-75-4, U.S. Army Engineer Waterways Experimental Station, Vicksburg, Miss.

Lee, G.F. et al., December 1977. Aquatic Disposal Field Investigations, Galveston, Texas, Offshore Disposal Sites; Appendix B: Investigation of Water-Quality Parameters and Physicochemical Parameters. Center for Environmental Studies, Richardson, Texas. Technical Report D-77-20, p. 435.

Lettau, B., Brower, W.A., Jr., and Quayle, R.G., 1976. Marine Climatology. MESA, New York. Bight Atlas Monograph 7.

Levinton, J., 1972. Stability and Trophic Structures in Deposit-Feeding and Suspension-Feeding Communities. The American Naturalist, Vol. 106, No. 950, pp. 472-485.

Lindberg, S.E. and Harriss, R.C., 1974. Mercury-Organic Matter Associations in Estuarine Sediments and Interstitial Water. Environmental Science & Technology, Volume 8, pp. 459-462.

Lonsdale, A.L., and Kaplan, H.R., 1964. A Guide to Sunken Ships in American Waters. Compass Publications Inc., Arlington, Va.

Madsen, O.S. and Grant, W., 1976. Sediment Transport in the Coastal Environment. MIT. Department of Civil Engineering, Report No. 209.

MAFC (Middle Atlantic Coastal Fisheries Center), 1974. Environmental Baselines in Long Island Sound, 1972-1973. NOAA-NMFS Sandy Hook.

Maine Department of Sea and Shore Fisheries and U.S. Army Corps of Engineers, New England Division, 1973. Third Ocean Disposal Conference, April 12-13, Fisheries Research Station, West Boothbay Harbor, Maine.

Malone, T.C., May 1977. Plankton Systematics and Distribution. MESA New York Bight Monograph 13, New York Sea Grant Institute, Albany, N.Y., 45p.

Manheim, F.T., Meade, R.H. and Bond, G.C., January 1970. Suspended Matter in Surface Waters of the Atlantic Continental Margin from Cape Cod to the Florida Keys. In: Science 167:371-376.

Manervity, Bernard, (Editor), 1975. Effects of Energy-Related Activities on the Atlantic Continental Shelf. Conference at Brookhaven National Laboratory, November 10-12, 1975, Associated Universities, Inc. Upton, N.Y., p. 260.

Marine Sciences Research Center, 1978. Dredged Material Research Program, Aquatic Disposal Field Investigations Eatons Neck Disposal Site Long Island Sound. Appendix B: Water-Quality Parameters and Physicochemical Sediment Parameters. Technical Report D-77-6 for U.S. Army Engineer Waterways Experiment Station at State University of New York, Stony Brook, N.Y.

Marr, P.D., Dec. 1975. A Bibliography of Regional Planning Reports. Regional Planning Contributions to Coastal Zone Planning in New York State. New York Sea Grant Institute NYSSGP-RS-75-027.

Marr, P.D., Aug. 1976. Governmental Jurisdictions of the New York Coastal Zone. An Analysis of Coastal Programs Summary. New York Sea Grant Institute p. 36.

Matthews, W.B. Jr., 1974. Marine Atlas Series - New England Series - Complete Charts. 105p.

Matthews, W.B. Jr., 1974. Marine Atlas Series - Long Island Sound & South Shore Series - Complete Charts, 105 p.

Maurer, D.L. et al., June 1978. Vertical Migration of Benthos in Simulated Dredged Material Overburdens; Vol. 1: Marine Benthos. University of Delaware, Lewes, Del. Technical Report D-78-35, p. 108.

McCall, Peter L., 1977. Community Patterns and Adaptive Strategies of the Infaunal Benthos of Long Island Sound. Journal of Marine Research Vol. 35, No. 2, pp. 221-226.

McCall, P.L., and Yingst, J.Y., 1978, Disturbance and Production on the Estuarine Seafloor. American Scientist, V. 676, pp. 577-586.

McCane, I.N., 1972. Transport and Escape of Fine-Grained Sediments from Shelf Areas. In: Shelf, DJP; Duane, D.B., and Pilkey (Editors), Shelf Sediment Transport: Process and Pattern. Dowden, Hutchinson and Keos, Stroudsbury, Pa., Chapter 10, pp. 225-248.

McClennen, Charles E., 1973. New Jersey Continental Shelf New Bottom Current Meter Records and Recent Sediment Activity Journal of Sedimentary Petrology, Vol. 43, No. 2, pp. 371-380, Fig. 1-5.

McGrath, R.A., 1974. Benthic Macrofauval Census of Raritan Bay - Preliminary Results. Pap. No. 24; Proc. 3rd Symp. Hudson R. Ecol.; Mar. 22-23, 1973, Bear Mt., N.Y.; Hudson R. Environ. Soc.

McHugh, J.L. and Ginter, J.J.C., January 1978. Fisheries. MESA New York Bight Atlas Monograph 16, New York Sea Grant Institute, Albany, N.Y., p. 129.

McHugh, J.L. and Williams, A.D., July 1976. Historical Statistics of the Fisheries of the New York Bight Area. New York Sea Grant Institute. p. 73.

McKinney, T.F., and Friedman, G.M., 1970. Continental Shelf Sediments of Long Island, New York J. Sedimentary Petrology. 40(1), pp. 213-248.

McMasters, R.L., and Garrison, L.E., 1967. A Submerged Holocene Shoreline Near Block Island, Rhode Island, J. Geol., Vol. 75, pp. 335-340.

McNulty, J.K., Work, R.C., and Moore, H.B., 1962. Some Relationships Between The Infauna of the Level Bottom and the Sediment - South Florida. Bulletin, Marine Sciences Gulf Carribean. 12:322-332.

Michael, A.D., 1975. Structure and Stability in three Marine Benthic Communities in Southern New England. In: Effects of Energy Related Activities on the Atlantic Continental Shelf. Conference at Brookhaven National Laboratory, Nov. 10-12, 1975, Upton, N.Y., pp. 109-125.

Michael, A.D. and others, 1975. Long-term Effects of An Oil Spill At West Falmouth. Proceedings of the Symposium on Prevention and Control of Oil Pollution. Published in American Petroleum Institute, EPA and U.S. Coast Guard, pp. 573-582.

Miller, A.R., April 1952. A Pattern of Surface Coastal Circulation Inferred from Surface Salinity-Temperature Data and Drift Bottle Recoveries. Woods Hole Oceanographic Institution, Technical Report, Reference No. 52-28.

Milliman, J.D., Pilkey, O.H., and Ross, D.A., May 1972. Sediments of the Continental Margin off the Eastern United States. Geol. Soc. of Amer. Bull. Vol. 83, pp. 1315-1334.

Mironov, O.G., 1970. The Effect of Oil Pollution on Flora and Fauna of the Black Sea. In: Proceedings, FAO Conference on Marine Pollution and Its Effects On Living Resources and Fish, December, 1970. Food and Agriculture Organization of the United Nations, Rome, Italy.

Mitre, 1979. Environmental Report on the Disposal of Dredged Material Within The New York District for Corps of Engineers, New York.

Moherek, A.J., June 1978. Flume Experiments on Sand, Silt, and Clay Mixtures from the Offshore Dredged Material Disposal Site, Galveston, Texas. Department of Oceanography, College Station, Texas. Technical Report D-78-34, p. 204.

Morgan, R.P. II, 1978. Final Report on Bioassays of Sediment from New Haven Harbor, to Army Corps of Engineers Battelle, Columbus Laboratories.

Morton, J.W., July 1973. A Selected Bibliography on Dredging and the Disposal of Dredge Spoils. Cornel University, Ithaca, N.Y. p. 23.

Morton, J.W., Cook, G.S., and Massey, A.T., 1975. A Summary of Environmental Data Obtained at the New London Dump Site and the East Hole, Block Island Sound. Technical Report, U.S. Naval Underwater Systems Center, Newport Laboratory.

Mosser, J.L., et al., 1972a. Polychlorinated Biphenyls: Toxicity to Certain Phytoplankters. Science 175: 191.

Mueller, J.A. and Anderson, A.R., January 1978. Industrial Wastes. MESA New York Bight Atlas Monograph 30. New York Sea Grant Institute, Albany, N.Y. 39 p.

Murray, J.W., 1975. The Interaction of Metal Ions at the Manganese Dioxide - Solution Interface. Geochim. Cosmochim. Acta, Volume 39, pp. 505-519.

Nathans, M.W. and Bechtel, T.J., November 1977. Availability of Sediment-Adsorbed Selected Pesticides to Benthos with Particular Emphasis on Deposit-Feeding Infauna. LFE Corporation, Richmond, California, Technical Report D-77-34, p. 83.

National Academy of Sciences, 1973. Water Quality Criteria 1972. EPA Ecol. Res. Series EPA-R3-73-033, U.S. Environmental Protection Agency, Washington, D.C.

National Marine Fisheries Service, Middle Atlantic Coastal Fisheries Center, Sandy Hook Laboratory, February 1972. The Effects of Waste Disposal in the New York Bight. Final Report-Section 4: Finfish Studies. National Marine Fisheries Service, Highlands, N.J., p. 10.

National Research Council, 1976. Disposal in the Marine Environment An Oceanographic Assessment - An Analytical Study for the U.S. Environmental Protection Agency. National Academy of Sciences, Washington D.C., 76p.

National Research Council, 1978. An Assessment of Mercury in the Environment, Prepared by Panel on Mercury of the Coordinating Committee for Scientific and Technical Assessments of Environmental Pollutants, Environmental Studies Board Commission at National Resources National Academy of Sciences, Washington, D.C.

Nature Conservancy, The, 1976. Virginia Coast Reserve Study. Volumes 1-3, Arlington, Virginia.

Neff, J.W., Foster, R.S. and Slowey, J.F., 1978. Availability of Sediment-Absorbed Heavy Metals to Benthos With Particular Emphasis on Deposit-Feeding Infauna. Technical Report D-78-42. DMRP, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

New England Aquarium, March 17, 1977. Critique and Proposal for the Management of Dredged Material in Massachusetts Bay Waters, Draft Final Report. For New England Division, Corps of Engineers, Waltham, Massachusetts. Contract No. DACW33-76-C-0096. 79p.

New England River Basins Commission, October 1973. Long Island Sound Regional Study, Sources and Movements of Water, An Interim Report, Prepared by USGS, Water Resources Div. and NOAA.

New England River Basins Commisison, July 1974. Long Island Sound Regional Study, An Economic Perspective, People and the Sound, Prepared by USDA, USDC.

New England River Basins Commission, January 1975. Long Island Sound Regional Study, People and the Sound, Outdoor Recreation, A planning Report by U.S. Dept. of Interior, Bureau of Outdoor Recreation.

New England River Basins Commission, January 1975. Long Island Sound Regional Study, People and the Sound, Erosion and Sedimentation, A Planning Report Prepared by USACOE and USDA, SCS.

New England River Basins Commission, January 1975. Long Island Sound Regional Study, People and the Sound, Flood Damage Reduction, A Planning Report, Prepared by USACOE of USDA-SCS.

New England River Basins Commission, Feb. 1975. Long Island Sound Regional Study, People and the Sound, Land Use. A policy Guide to Land Use, by Ralph M. Field and Associates for the U.S. Dept. of Housing and Urban Development.

New England River Basins Commission, February 1975. Long Island Sound Regional Study, People and the Sound Shoreline Appearance and Design. A Planning Report Prepared by Ray Mann Associates, Inc. for USDI, NPS.

New England River Basins Commission, February 1975. Long Island Sound Regional Study, People and the Sound, Marine Transportation, A Planning Report, Prepared by USACOE.

New England River Basins Commission, March 1975. Long Island Sound Regional Study People and the Sound, Water Management, A Planning Report, Prepared by USEPA Comm. Dept. of Environmental Protection, N.Y. State Dept. of Environmental Conservation.

New England River Basins Commission, May 1975. Long Island Sound Regional Study, People and the Sound, Mineral Resources and Mining. A planning Report by Eastern Field Operations Center, U.S. Bureau of Mines and USACOE.

New England River Basins Commission, May 1975. Long Island Sound Regional Study, People and the Sound, Power and the Environment, A Planning Report, by New York Regional Office of the Federal Power Commission.

New England River Basins Commission, 1975. Long Island Sound Regional Study, People and the Sound, A Plan for Long Island Sound - Summary Vol. I, Summary.

New England River Basins Commission, December 1975. Report of the Southeastern New England Study, Regional Report.

New England River Basins Commission, December 1975. Report of the Southeastern New England Study, 9. Narragansett Bay and Block Island - Planning Area Report.

New England River Basins Commission, December 1975. Report of the Southeastern New England Study - Summary 49p.

New England River Basins Commission, Coastal Programs Division, June 21, 1979. Review Draft, Interim Plan for the Disposal of Dredged Material in Long Island Sound.

New York Ocean Science Laboratory, Feb. 1974. An Interdisciplinary Study of the Estuarine and Coastal Oceanography of Block Island Sound and Adjacent New York Coastal Waters: Ground Truth, Final Report, Hollman R. - Staff Coordinator, under Contract NASS-21792, 93 p.

New York, State of - Dept. of Environmental Conservation & Connecticut, State of - Dept. Of Environmental Protection, April 1977. Interim Program for the Disposal of Dredged Material In Long Island Sound - A Summary, 10 p.

Nicholas, M.M. et al., July 1978. A Field Study of Fluid Mud Dredged Material: Its Physical Nature and Dispersal, WES Technical Report D-78-40, Prepared by the Virginia Institute of Marine Science and Lafayette College at Easton for the Environmental Laboratory (Work Unit 6CD7).

Ninety-Fourth Congress, First Session U.S. House of Representatives, Committee on Science and Technology, Subcommittee on the Environment and Atmosphere, September 17, 18, 19, 24, 26, 1975. Hearings on the Environmental Effects of Dumping in the Oceans and Great Lakes. Congressional Information Service, Washington, D.C. p. 1000.

Nisbet, I.C.T. and Sarofin, A.F., 1972. Rates and Routes of Transport of PCBs in the Environment. Environmental Health Perspect (April): 21-38.

Nissenbaum, A. and Swaine, D.J., 1976. Organic Matter-metal Interactions in Recent Sediments: The Role of Humic Substances. Geochim. Cosmochim. Acta , Volume 40, pp.809-816.

NOAA, January 1975. Report to the Congress on Ocean Pollution, Overfishing, and Offshore Development - July 1973 through June 1974 NTIS U.S. Department of Commerce - Com-75-10509.

NOAA, April 1977. Physical, Chemical and Biological Effects of Dredging in the Thames River (CT) and Spoil Disposal at the New London (CT) Dumping Ground. Final Report to U.S. Navy & Interagency Scientific Advisor Subcommittee on Ocean Dredging & Spoiling by NOAA, National Marine Fisheries Service, Northeast Fisheries Center Division of Environmental Assessment Report No. 2.

NOAA-ERL, May 1975. New York Bight Project, Water Column Data, NOAA Ship Researcher, 1974, Spring Cruise, Legs II, V. Prepared by Charnell, R.L., Darnell, M.E., Berberian, G.A. et al., Atlantic Oceanographic and Meteorlogical Laboratories, May 1975.

NOAA-MESA, Charnell, R.L. (Editor), April 1975. Assessment of Offshore Dumping; Technical Background: Physical Oceanography, Geological Oceanography and Chemical Oceanography. NOAA. Technical Memorandum ERL MESA-1. U.S. Department of Commerce, 212 p.

NOAA-MESA, February 1976. Evaluation of Proposed Sewage Sludge Dumpsite Areas in the New York Bight. NOAA Technical Memorandum ERL MESA-11: U.S. Department of Commerce, 212 p.

NOAA-MESA, April 1976. *Contaminant Inputs to the New York Bight.* NOAA Technical Memorandum, Environmental Research Laboratories (ERL) MESA-6. U.S. Department of Commerce 347 p.

NOAA-NMFS, April 1972. The Effects of Waste Disposal in the New York Bight. Summary Final Report. Middle Atlantic Coastal Fisheries Center, Informal Report No. 2., 70p.

NOAA-NMFS, March 15, 1974. Coliform and Metal Concentrations in Sediments from the Atlantic and Long Beach Area - New York Bight. NOAA, Middle Atlantic Coastal Fisheries Center, Informal Report No. 22.

NOAA-NMFS, September 1974. Distribution of Five Metals in Sediments from the New York Bight. NOAA, Middle Atlantic Coastal Fisheries Center, Informal Report No. 36.

NOAA-NMFS, January 1975. Ratios of Metals in Sediments Collected from the New York Bight. NOAA, Middle Atlantic Coastal Fisheries Center, Informal Report No. 44.

NOAA-NMFS, February 12-24, 1975. Cruise Report - NOAA Ship Delaware II. Middle Atlantic Coastal Fisheries Center, Sandy Hook Laboratory.

NOAA-NMFS, 1975. An environmental survey of effects of dredging and spoil disposal, New London, CT. 5th Quarterly Report. Informal Report No. 84, November 1975.

NOAA-NMFS, Northeast Fisheries Center, February 1977. Oxygen Depletion and Associated Environmental Disturbance on the Middle Atlantic Bight in 1976: A Report on a Series of Interagency Workshops Held in November and December 1976. Technical Series Report No. 3., Dept of Commerce, Sandy Hook, N.J., 471 p.

NOAA-NOS, 1977. Tidal Current Charts, Long Island Sound and Block Island Sound, Sixth Edition.

NOAA-NOS, 1977. Cape Sable to Cape Hatteras. Chart No. 13003, 1:1,200,000. Approaches to New York - Nantucket Shoals to Five Fathom Bank. Chart No. 12300, 1:400,000. Long Island Sound, Western Part. Chart No. 12363, 1:80,000. Long Island Sound Eastern Part. Chart No. 12354, 1:80,000. Approaches to New York Fire Island Light to Sea Girt Light. Chart No. 12326, 1:80,000.

NOAA-NOS, 1978. Block Island Sound and Approaches. Chart No. 13205, 1:80,000. Block Island Sound and Gardeners Bay. Chart No. 13209, 1:40,000. Martha's Vineyard to Block Island. Chart No. 13218, 1:80,000. Block Island Sound. Chart No. 13215, 1:40,000.

NOAA-NOS, 1978. United States Coast Pilot, Atlantic Coast - Cape Cod to Sandy Hook - No. 2.

NOAA-NOS, (no date). Tidal Current Charts, Narragansett Bay to Nantucket Sound. Third Edition.

NOAA, U.S. Dept. of Commerce, 1974. Bibliography of the New York Bight, Part 1 - List of Citations. Marine Ecosystems, Analysis (MESA) Program, Office of Coastal Environments, Prepared by Environmental Science Information Center, Environmental Data Service, 184p.

NOAA, U.S. Dept. of Commerce, 1974. Bibliography of the New York Bight, Part 2 - Indexes, Marine Ecosystems Analysis (MESA) Program, Office of Coastal Environments, Prepared by Environmental Science Information Center, Environmental Data Service, 493p.

NUSC, 1975. DAMOS, Disposal Area Monitoring System Annual Data Report -1975. Naval Underwater Systems Center, Newport, Rhode Island.

Nuzzi, Robert, 1977. Dredged Material Research Program, Aquatic Disposal Field Investigation Eaton Neck Disposal Site, Long Island Sound, Appendix F: Predisposal Baseline Conditions of Phytoplankton Assemblages. New York Ocean Science Laboratory, for U.S. Army Engineer Waterways Experiment Station Technical Report D-77-6.

O'Connor, D.J., Thoman, R.V., Salas, H.J., October 1977. Water Quality - MESA New York Bight Atlas Monograph 27, New York Sea Grant Institute, Albany.

O'Connor, J.S., 1973. Dredging and Spoiling on Long Island. Marine Sciences Center Technical Report 19. Stony Brook, N.Y.: State University of New York.

O'Connor, T.P., and Kester, D.R., 1975. Adsorption of Copper and Cobalt from Fresh and Marine Systems. Geochim. Cosmochim. Acta, Volume 39, pp. 1531-1543.

Olsen, Stephen B., Stevenson, David K., 1975. Commercial Marine Fish and Fisheries of Rhode Island, The Coastal Resources Center, University of Rhode Island, Marine Technical Report 34.

O'Neal, G., Sceva, J., July 1971. The Effects of Dredging on Water Quality in the Northwest, U.S. EPA, Office of Water Programs, Region X, Seattle, Washington, 158 p.

O'Neill, T.M., January 1974. Ocean Disposal of Waste Off New Jersey, In: Commentary, NJDEP Vol. I, No. 2, 31 p.

Oriatt, C.A., Nixon, S.W., 1973. The Demersal Fish of Narragansett Bay: An Analysis of Community Structure, Distribution and Abundance. Graduate School of Oceanography, NOAA Sea Grant University of Rhode Island, Marine Report #19 Reprinted from Estuarine & Coastal Marine Sciences Vol. I, 361-378.

Oriatt, Candace A., and Nixon, Scott W., 1975. Sediment Resuspension and Deposition in Narragansett Bay. Graduate School of Oceanography, University of Rhode Island. Estuarine and Coastal Marine Science 3 201-217.

Palmer, H.D. and Gross, M.G. (Editors), 1979. Ocean Dumping and Marine Pollution: Geological Aspects of Waste Disposal. Danden, Hutchinson & Ross, Inc.

Pararas-Carayannis, George, May 1973. Ocean Dumping in the New York Bight: An Assessment of Environmental Studies U.S. Army Corps of Engineers Coastal, Engineering Research Center Technical Memorandum No. 39, p. 159.

Parrish, P.R., 1974. Aroclor 1254, DDT and DDE, Dieldrin. Accumulation and Loss of American Oysters Crassostrea Virginica Exposed Continuously For 56 Weeks. Pro. Nat. Shellfish Assoc. 64:7.

Paskausky, D.F. and Murphy, D.L., 1976. Estuarine & Coastal Marine Science Vol. 4, 513-522 Seasonal Variation of Residual Drift in Long Island Sound.

Pavlon, S.P. et al., January 1978. Aquatic Disposal Field Investigations Duwamish Waterway Disposal Site, Puget Sound, Washington; Appendix E: Release and Distribution of Polychlorinated Biphenyls Induced by Open-Water Dredge Disposal Activities. Department of Oceanography, Seattle, Washington. Technical Report D-77-24, p. 546.

Pearce, J.B., 1972. The effect of solid waste disposal on benthic communities in New York Bight. In: M. Runo, Ed., Marine Pollution and Sea Life. Fishing News, Ltd., Surrey, England, pp. 404-411.

Peddicord, R.K. and McFarland, V.A., 1978. Effects of Suspended Dredged Material on Aquatic Animals. Technical Report D-78-29. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Pequegnat, W.E. et al., January 1978. Tereco Corp., College Sta., Texas, An assessment of the Potential Impact of Dredged Material Disposal in the Open Ocean, Final Report. Dredged Material Research Program, Technical Report D-78-2. U.S. Army Engineer Waterways Experimentatal Station, Environmental Effects Laboratory, Vicksbury, Miss. 642 p.

Pore, N.A. and Barrientos, C.S., April 1975. Storm Surges of the New York Bight NOAA - Techniques Development Laboratory National Weather Service, Silver Springs, Maryland.

Pore, N.A. and Barrientos, C.S., February 1976. Storm Surge. MESA New York Bight Atlas Monograph 6. New York Sea Grant Institute, Albany, N.Y. 43 p.

Powers, C.F., June 1955. Circulation and Water Transport in the Coastal Area Between Martha's Vineyard and Barnegat Inlet, New Jersey. Cornell University Doctoral Dissertation Series Publication No. 15, 423.

Pratt, S.D. and Connor, R.O., 1970. "Benthic Fauna," Coastal and Offshore Environmental Inventory, Cape Hatteras to Nantucket Shoals, Marine Publication Series No. 2, University of Rhode Island, Narragansett, R.I.

Pratt, S.D., and Connor, R.O., 1973. Burial of Dredge Spoil in Long Island Sound, Report to Normandeau Associates for United Illuminating Company New Haven, Connecticut.

Pratt, R.M. and Schlee, J., November 1969. Glaciation on the Continental Margin Off New England. Geol. Soc. of American Bulletin, Vol. 80, pp. 2335-2342.

Presley, B.J., Kolodny, Y., Nissenbaum A., and Kaplan, I.R., 1972. Early Diagenesis in a Reducing Fjord, Saanich Inlet, British Columbia - II. Trace Element Distribution in Interstitial Water and Sediment. Geochim. Cosmochim. Acta, Volume 36, pp. 1073-1090.

Pringle, B.H., D.E. Hissong, Katz, D.E., and Mulawka, S.T., 1968. Trace Metal Accumulation by Estuarine Mollusks. Journal of the Sanitary Division, American Society of Civil Engineers, Volume 94, pp. 455-463.

Pritchard, D.W., 1967. Observations of Circulation in Coastal Plain Estuaries. In: Estuaries. Editor - Lauff, G.H., Publ. No. 83. American Association Advanced Science, Washington, D.C.

Prosser, G.C., and Brown, F.A., 1961. Comparative Animal Physiology. Second Edition, W.B. Saunders Co., Philadelphia, Pa.

Rashid, M.A., 1974. Adsorption of Metals on Sedimentary and Peat Humic Acids. Chemical Geology, Volume 13, pp. 115-123.

Raytheon Oceanographic and Environmental Services Co., November 21, 1975. Baseline Survey - New York Bight, Cruise 1, Sept. to Oct. 1974, Vol. VI - Data Report EPA Contract 68-01-2770.

Raytheon Oceanographic and Environmental Services Co., November 21, 1975. Baseline Survey - New York Bight, Cruise 3, July-August 1975, Vol. I, III, IV, V, VI, & VII, EPA Contract 68-01-2770.

Regional Marine Resources Council, 1973. Guidelines for Long Island Coastal Management Committee of the Nassau Suffolk Regional Planning Board.

Research Institute of the Gulf of Maine, Portland, May 1976. Summary of Environmental Information on the Continental Slope Canadian/United States Border to Cape Hatteras, N.C., Chapters 1 through 6 Prepared for Bureau of Land Management N.Y. Marine Minerals Division.

Rhoads, D.C., 1973. The Influence of Deposit-Feeding Benthos on Water Turbidity and Nutrient Recycling. Am. J. Science p.273, pp. 1-22.

Rhoads, D.C., 1974. Organism - Sediment Relations on the Muddy Sea Floor. Oceanogr. Mar. Bio. Am. Rev. 12, pp. 263-300.

Rhoads, D.C., McCall, P.L., and Yingst, J.Y., 1978. Disturbance and Production on the Estuarine Seafloor, American Scientist, Vol. 66, pp. 577-586.

Rhoads, Donald, 1972. The Environmental Consequences of Dredge Spoil Disposal in Central Long Island Sound: I. Benthic Biology of the New Haven Dump Site. Unpublished Report to U.S. Army Corps of Engineers and the United Illuminating Co. 40 p.

Rhoads, Donald, 1973. The Environmental Consequences of Dredge Spoil Disposal in Central Long Island Sound: VI. Benthic Biology of the New Haven Dump Site, South Control, and Northwest Control Sites. Unpublished Report to U.S. Army Corps of Engineers, 5 p.

Rhoads, Donald, 1973a. The Environmental Consequences of Dredge Spoil Disposal in Central Long Island Sound: II. Benthic Biology of the New Haven Harbor Channel and Northwest Control Site. Unpublished Report to U.S. Army Corps of Engineers and the United Illuminating Co. 61 p.

Rhoads, Donald, 1973a. The Environmental Consequences of Dredge Spoil Disposal in Central Long Island Sound: VII. Benthic Biology of the New Haven Ship Channel, Dump Site, South and Northwest Control Sites, Summer 1973. Unpublished Report to U.S. Army Corps of Engineers and the United Illuminating Co. 64 p.

Rhoads, Donald, 1973b. The Environmental Consequences of Dredge Spoil Disposal in Central Long Island Sound: III. Benthic Biology of the South Control Site, 1972. Unpublished Report to U.S. Army Corps of Engineers and the United Illuminating Co. 44 p.

Rhoads, Donald, 1973d. The Environmental Consequences of Dredge Spoil Disposal in Central Long Island Sound: V. Benthic Biology of the Milford, Branford, and Guilford Dump Grounds. Unpublished Report to U.S. Army Corps of Engineers and United Illuminating Co. 38 p.

Rhoads, Donald, 1974a. The Environmental Consequences of Dredge Spoil Disposal in Central Long Island Sound: VIII. Changes in Spatial and Temporal Abundance Patterns of Benthic Molluscs Sampled from New Haven Harbor Dump Site, South and Northwest Control Sites, 1972-1973 (Pre-dump Baseline). Unpublished Report to U.S. Army Corps of Engineers and the United Illuminating Co. 49 p.

Rhoads, Donald, 1974b. The Environmental Consequences of Dredge Spoil Disposal in Central Long Island Sound: IX. Benthic Biology of the New Haven Harbor Ship Channel, New Haven Dump Site, New South Control and Northwest Control Sites, February-March, 1974 (During Dredging and Dumping Operations). Unpublished Report to U.S. Army Corps of Engineers. 50 p.

Rhoads, Donald, 1974c. The Environmental Consequences of Dredge Spoil Disposal in Central Long Island Sound: X. Benthic Biology of the New Haven Harbor Ship Channel, New Haven Dump Site, New South Control and Northwest Control Sites, July 1974 (Postdredging and Dumping). Unpublished Report to U.S. Army Corps of Engineers, 79 p.

Rhoads, Donald, Aller, R.C. and Goldhaber, M.B., 1975. The Environmental Consequences of Dredge Spoil Disposal in Central Long Island Sound: XI. The Influence of Colonizing Benthos on Physical Properties and Chemical Diagenesis of the New Haven Dump Site. Unpublished Report to U.S. Army Corps of Engineers, 45 p.

Rhode Island Statewide Planning Program, 1977. Areawide Water Quality Management Plan - Preliminary Evaluation of the Water Quality Impacts of Hydrologic Modifications, Dection 208-Federal Water Pollution Control Act of 1972, 30 pt Appendicies.

Rhode Island Statewide Planning Program, 1978. Areawide Water Quality Management Plan-Recommended Leachate Control Alternations, Section 208-Federal Water Pollution Control Act of 1972, Prepared by Roy F. Weston, Inc. West Chester, Pa., 79 p & Bibliography.

Rhode Island Statewide Planning Program, 1978. Preliminary Draft: Rhode Island Areawide Water Quality Management Plan, Section 208-Federal Water Pollution Control Act of 1972, 517 p.

Rhode Island, University of: Marine Experiment Station, 1973. Coastal and Offshore Environmental Inventory - Cape Hatteras to Nantucket Shoals, University of Rhode Island - Marine Publication Series, Salia, Saul B. - Coordinator.

Richards, Sarah W., 1963. The Demersal Fish Population of Long Island Sound, Vol. 18, Article 2, Bull. of the Bingham Oceanographic Collection.

Riley, G.A., 1952. Hydrography of the Long Island and Block Island Sounds, Bulletin of the Bingham Oceanographic Collection, Vol. 13, Int. 3, pp. 5-39.

Riley, G.A. 1955. Review of the Oceanography of Long Island Sound. Deep Sea Res., Suppl. to Vol. 3:224-238.

Riley, G.A., 1956. Oceanography of Long Island Sound, 1952-1954. II. Physical Oceanography, Bull. Bingham. Oceanogr. Coll. 15:15-46. or if in Chemical Section — III. Chemical Oceanography ... Coll. 15:47-61.

Riley, G.A., 1959. Note on Particulate Matter in Long Island Sound. Bulletin of the Bingham Oceanographic Collection 17; pp. 83-85.

Riley, G.A., 1967. The Plankton of Estuaries In: Estuaries, G.H. Lauff, ed. AAAS Publication No. 83, Washington, D.C.

Riley, G.A. and Conover, S.M., 1967. Phytoplankton of Long Island Sound 1954-1955. Bull. Bingham. Oceanogr. Coll., 19:5-34.

Riley, J.P. and Chester, R., 1971. Introduction to Marine Chemistry. Academic Press; New York.

Rittenberg, S.C., Mittwer, T., and Ivler, D., 1958. Coliform Bacteria in Sediments Around Three Marine Sewage Outfalls. Limnology and Oceanography 3:101-108.

Roberts, J.R., Rodgers, D.W., Bailey, J.R. and Rorke, M.A., 1978. Polychlorinated Biphenyls: Biological Criteria for an Assessment of Their Effects on Environmental Quality. Associate Committee on Scientific Criteria for Environmental Quality, National Research Council, Canada.

Rohatgi, N., and Chen, K.Y., 1975. Transport of Trace Metals by Suspended Particulates on Mixing with Seawater. J. Water Pollution Control Fed. 47, pp. 2298-2316.

Rolston, J.L., Banach, F.S., Handman, E.H., 1978. A Map of Surface Water Quality & Built-up Areas in Connecticut, Scale: 1: 125,000, Based on a 1970 Land Use Map, MF-981-C.

Rolston, J.L., Bingham, J.W., 1978. Nonsewered Built-Up Areas and Septage Disposal Sites in Connecticut, Scale: 1: 125,000, MF-981-E.

Rolston, J.L., Handman, E.H., Groosman, I.G., 1978. Industrial Areas and Ground Disposal of Industrial Wastes in Connecticut, Scale: 1: 125,000, MF-981-D, Based on a 1970 Land Use Map.

Rudd, H. and Malloy, W., 1979. Thames Dredge and Dock Co., New London, Conn., Personal Communication.

Ryther, J.H., 1954. The Ecology of Phytoplankton Blooms in Moriches Bay and Great South Bay Long Island, New York. Biological Bulletin, 106:195-209.

Saila, S.B., Pratt, S.D., and Polgar, T.T., 1971. Providence Harbor improvement spoil disposal site evaluation study — Phase II. Rep. to Bureau of Sport Fish. and Wildl., Mar. Exper. Sta., Univ. of Rhode Island, Kingston, R.I.

Saila, S.B., Pratt, S.D., Polgar, T.T., 1972. Dredge Spoil Disposal in Rhode Island Sound, Univ. of Rhode Island, Kingston, R.I.

Salwen, Bert, 1962. Sea Levels and Archaeology in the Island Sound Area, American Antiquity Vol. 28, No. 1 pp 46-55.

Sanders, H.L., 1956. Oceanography of Long Island Sound, 1952-54, 10: The biology of marine bottom communities, Bull. Bingham. Oceanogr. Coll. 15:345-414.

Sanders, J.E., Emery, K.O., and Uchupi, E., April 1969. Microtopography of Five Small Areas of the Continental Shelf by Side-Scan Sonar. Geol. Soc. of Amer. Bull. Vol. 80, pp. 561-572.

Sawyer, C.N. and McCarty, P.L., 1978. Chemistry for Environmental Engineering, Third Ed., McGraw-Hill, Inc., New York, p. 532.

Schlee, J., 1968. Sand and Gravel on the Continental Shelf Off the Northeastern United States. Geological Survey Circular 602, p. 9.

Schlee, J. and Pratt, R.M., 1970. Atlantic Continental Shelf and Slope of the United States - Gravels of the Northeastern Part. Geological Survey Professional Paper 529-H, pp. 39.

Schlee, J. and Sanko, P., July 1975. Sand and Gravel. MESA New York Bight Atlas Monograph 21, New York Sea Grant Institute, Albany, N.Y. p. 26.

Schuba, P.J. and others. Biological Assessment Methods to Predict the Potential Environmental Impact of Open-water Disposal of Dredged Material. Tech. Rep, (in preparation), U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Mississippi.

Schubel, J.R., 1975. Distribution and Transportation of Suspended Sediments, In: Effects of Energy Related Activities on the Atlantic Continental Shelf. Conference at Brookhaven National Laboratory, Nov. 10-12, 1975, Upton, N.Y., pp. 207-230.

Schubel, J.R. and Hirschberg, D.J., 1978. Estuarine Graveyards, Climatic Change and the Importance of the Estuarine Environment. Estuarine Interactions Academic Press, Inc., pp. 285-303.

Schubel, J.R. and Okudo, A., 1972. Comments on the Dispersal of Suspended Sediments Across the Continental Shelves, In Swift, P.J.P. Duane, D.B. and Pilkey, O.H. (Editors), Shelf Sediment Transport: Process and Pattern, Chapter 15, pp. 333-346. Dowden, Hutchinson and Ross, Inc. Stroudsbury, Pa.

Schubel, J.R., and Wise, W.M., (Editors), 1979. Questions About Dredging and Dredged Material in the Chesapeake Bay. Maryland Department of Nautral Resources, Special Report 20, Reference 79-3, 143p.

Schubel, J.R. et al., July 1978. Field Investigations of the Nature, Degree, and Extent of Turbidity Generated by Open-Water Pipeline Disposal Operations. Marine Sciences Research Center, Stony Brook, N.Y. Technical Report D-78-30, p. 297.

Science, June 1967. Reports: Elephant Teeth from the Atlantic Continental Shelf. Science Vol. 156, pp 1477-1480.

Scott, J.T. and Csanady, G.T., October 1976. Nearshore Currents Off Long Island, Journal of Geophysical Research Vol. 81, No. 30 pp. 5401-5409.

Seavey, G.L., and Pratt, S.D., 1979. The Disposal of Dredged Material in Rhode Island: An Evaluation of Past Practices and Future Options. Coastal Resource Center, University of Rhode Island, Marine Technical Report 72, p. 96.

Segar, D.A., (No Date). A Review of the Impact of Dredged Material Disposal in the New York Bight Apex, with Emphasis on Chemical Processes. (Rough Draft).

Segar, D.A. and Cantillo, A.Y., 1976. Trace Metals in the New York Bight, In: Middle Atlantic Continental Shelf and the New York Bight. Amer. Soc. Limnol. Oceanog. Spec. Symp. Vol. 2, pp. 171-198.

Segar, D.A. and Berberian, G.A., 1976. Oxygen Depletion in the New York Bight Apex: Cause and Consequence, In: Middle Atlantic Continental Shelf and the New York Bight. Am. Soc. Limnol. Oceanog. Spec. Symp., Vol. 2, pp. 220-239.

Serafy, D.K., 1973. NYOSL benthic invertebrate studies: Past and present. Paper presented at 6th Long Island Sound Conference, Montauk, N.Y. 1 December 1973.

Serafy, D.K., Hartzband, D.J. et al., 1977. Dredged Material Research Program - Aquatic Disposal Field Investigations Eatons Neck Disposal Site Long Island Sound, Appendix L: Predisposal Baseline Conditions of Benthic Assemblages. Technical Report D-77-6 for U.S. Army Engineer Waterways Experiment Station by New York Ocean Sciences Laboratory.

Shelton, T.B. and Hunter, J.V., 1975. Anaerobic Decomposition of Oil in Bottom Sediments. J. Wat. Pollut. Conr. Feder. 47:2256-2270.

Shepard, F.P., December 30, 1932. Sediments of the Continental Shelves. Geol. Soc. of Amer. Bulletin, Vol. 43, pp. 1017-1040.

Shepard, F.P., 1963. Submarine Geology Sed. Harper and Row, New York, N.Y. pp. 557.

Shepard, F.P. and Cohee, G.U., 1936. Continental Shelf Sediments Off the Mid Atlantic States. Bull. Geol. Soc. Amer. 47, pp. 441-457.

Shortnose Sturgeon Recovery Team, 1977. A compendium of recent records on shortnose sturgeon from Canada to Florida, Philadelphia, Pa. 8/31-9/1/77.

Shuba, P.J., Tatem, H.E., & Carroll, J.H., August 1978. Biological Assessment Methods to Predict the Impact of Open-Water Disposal of Dredged Material. WES Technical Report D-78-50 Environmental Laboratory (Work Unit 1E08).

Silberman, J., January, 1980. U.S. Coast Guard District III, Personal Communication.

Sindermann, C.J., 1976. Effects of Coastal Pollution on Fish and Fisheries - With Particular Reference to the Middle Atlantic Bight, In: Middle Atlantic Continen tal Shelf and New York Bight. Am. Soc. Limnol. Oceanog. Spec. Symp. Vol. 2, pp. 281-301.

Sissenwine, M.P., 1974. Variability in Recruitment and Equilibrium Catch of the Southern New England Yellowtail Flounder Fishery. Marine Experiment Station, NOAA Sea Grant University of Rhode Island, Marine Reprint No. 31 Reprinted J. Cons. Int. Explor. Mar. 36(1) 15-26.

Sissenwine, M.P., Saila, S.B., 1974. Rhode Island Sound Dredge Spoil Disposal and Trends in the Floating Trap Fishery Marine Experiment Station NOAA Sea Grant, University of Rhode Island, Marine Reprint No. 30. Reprinted from Transactions of the American Fisheries Society, Vol. 103, No. 3, pp. 498-505.

Smayda, T.J., 1975. Plankton Processes in Mid-Atlantic Nearshore and Shelf Waters and Energy-Related Activities. In: Effects of Energy-Related Activities on the Atlantic Continental Shelf. Conference at Brookhaven National Laboratory Nov. 10-12, 1975, Upton, N.Y., pp. 70-95.

Souder, P.S. et al., June 1978. "Dredged Material Transport Systems for Inland Disposal and/or Productive Use Concepts," WES Technical Report D-78-28 Prepared by General Research Corp. for the Environmental Laboratory (Work Unit 3BO1).

Staff, N., February 1974. An Interdisciplinary Study of the Estuarine and Coastal Oceanography of Block Island Sound and Adjacent New York Coastal Waters Final Report. New York Ocean Science Laboratory Technical Report No. 0027.

Stanley, D.J., 1969. Atlantic Continental Shelf and Slope of the United States - Color of Marine Sediments. Geological Survey Professional Paper 529-D, 15p.

Sternberg, R.W., 1971. Measurement of Incipient Motion of Sediment Particles in the Marine Environment. Marine Geology, 10(2): 113-119 (Printed in the Netherlands).

Sternberg. R.W., 1972. Predicting Initial Motion and Bedload Transport of Sediment Particles in the Shallow Marine Environment, Shelf Sediment Transport - Process and Pattern (Edited by: Swift, D.J.P., Duane, D.B. and O.H. Pilkey), Chap. 3, Dowden, Hutchinson & Ross, Inc.

Sternberg, R.W., 1975. Stability of Dredged Material Deposited at Ocean Dumping Sites Seaward of the Columbia River Mouth.

Sternberg, R.W., Greager, J.S., Johnson, J. et al., 1977. Stability of Dredged Material Deposited at Ocean Dumping Sites Seaward of the Columbia River Mouth, Dept. of Oceanography, Univ. of Washington, Seattle, Washington.

Strosher, M.T. and Hodgson, G.W. 1975. Polycyclic aromatic hydrocarbons in lake waters and associated sediments: analytical determination by gas chromatography-mass spectrometry, American Society for Testing and Materials, Special Tech. Publ. 573. Water Quality Parameters. American Society for Testing and Materials, Philadelphia, Pennsylvania.

Stumm, W. and Morgan, J.J., 1970. Aquatic Chemistry. Wiley-Interscience; New York.

Suter, R., DeLoguna, W., and Perlmutter, N.M., 1949. Mapping of Geologic Formations and Aquifers of Long Island, New York. New York State Water Power and Control Com. Bulletin GW-18 Albany, N.Y. 212p.

Sutherland, January, 1980. U.S. Coast Guard District I.

Swanson, R.L., January 1976. Tides. MESA New York Bight Atlas Monograph 4 New York Sea Grant Institute, Albany, N.Y. 34p.

Sweeney, R.A., June 1978. Aquatic Disposal Field Investigations, Ashtabula River Disposal Site, Ohio; Evaluative Summary. Great Lakes Laboratory, Buffalo, N.Y. Technical Report D-77-42, p. 125.

Swift, D. et al., 1975. Geological Oceanography; Sedimentation in the New York Bight Apex and Application to Problems of Waste Disposal. NOAA Technical Memorandum ERL MESA-1.

Swift, D.J.P., 1972. Implications of Sediment Dispersal from Bottom Current Measurements. Some Specific Problems in Understanding Bottom Sediment Distribution and Dispersal on the Continental Shelf - A Discussion of two Papers. In: Swift, D.J.P., Duane, D.B and Pilkey, O.H. (Editors) Shelf Sediment Transport: Process and Pattern, Chapter 17, pp. 363-371, Dowden, Hutchinson and Ross, Stroudsburg, Pa.

Swift, D.J.P., Duane, D.B. and Pilkey, O.H. (Editors), 1972. Shelf Sediment Transport: Process and Pattern. Dowden, Hutchinson and Ross, Stroudsburg, Pa.

Swift, D.J.P., Ludwick, J.C. and Boehmer, W.R., 1972. Shelf Sediment Transport: A Probability Model, Chapter 9, In: Swift, D.J.P., Duane, D.B. and Pilkey O.H. (Editors), Shelf Sediment Transport. Dowden, Hutchinson & Ross, Inc., Stroudsburg, Pa., pp. 195-223.

Swift, D.J.P. and Palmer, H.D., 1978. Coastal Sedimentation Benchmark Papers in Geology Vol. 42, Dowden, Hutchinson & Ross, Inc.

Swift, D.J.P. et al., 1976. Morphologic Evaluation and Coastal Sand Transport, New York-New Jersey Shelf. Spec Symp. pp. 69-89. In: Am. Soc. Limnol. Oceanogs.

Tagg, A.R. and Uchupi, E., 1967. Subsurface Morphology of Long Island Sound, Block Island Sound, Rhode Island Sound and Buzzards Bay Contribution No. 1860 of the Woods Hole Oceanographic Institution in U.S. Geological Survey Prof. Paper 575-C pp. 642-696.

Teeny, F.M. and Hall, A.S., November 1977. Aquatic Disposal Field Investigation, Duwamish Waterway Disposal Site, Puget Sound, Washington; Appendix C: Effects of Dredged Material Disposal on the Concentration of Mercury and Chromium in Several Species of Marine Animals. Northwest and Alaska Fisheries Center, Seattle, Washington. Technical Report D-77-24, p. 22.

Terry, O.W., June 1977. Aquaculture. MESA New York Bight Atlas Monograph 17, New York Sea Grant Institute, Albany, New York. 36p.

Terwindt, J.H.J. and Breusers, H.N.C., 1972. Experiments on the Origin of Flasher, Lenticular and Sandy-Clay Alternating Bedding. Sed., pp. 19, 85-98.

Thomas, J.P., et al., 1976. Seabed Oxygen Consumption - New York Bight Apex. American Society of Limnology and Oceanography, Special Symposium No. 2, pp. 354-369.

TRIGOM-PARC, Research Institute of the Gulf of Maine (TRIGOM) and Public Affairs Research Center (PARC), November, 1974. A Socio-Economic and Environmental Inventory of the North Atlantic Region, Including the Outer Continental Shelf and Adjacent Waters from Sandy Hook, New Jersey, to Bay of Fundy. 3 Volumes, Books Submitted to BLM Marine Minerals Division Under Contract 08550-CT3-8.

Uchupi, E., 1963. Sediments on the Continental Margin Off Eastern U.S. U.S.G.S. Prof. Paper 475-C, p. C132-137.

Uchupi, E., 1970. Atlantic Continental Shelf and Slope of the United States - Shallow Structure. Geological Survey Professional Paper 529-I, 44 p.

U. S. Army Corps of Engineers, 1975a. Dredge Disposal Study, San Francisco Bay and Estuary. Appendix H, Pollutant Uptake Study. September 1975, San Francisco District.

U. S. Army Corps of Engineers, 1975b. Dredge Disposal Study, San Francisco Bay and Estuary. Appendix I, Pollutant Availability Study. October 1975, San Francisco District.

U.S. Army Corps of Engineers, Interagency Scientific Subcommittee on Ocean *Dredging and Spoiling (ISASODS), 1974-1977, 1973-1974. Notes & Letters.*

U.S. Army Corps of Engineers, 1977. Waterborne Commerce of the United States. Part X Waterways and Harbors, Atlantic Coast. U.S. Army Engineer Division, Vicksburg, Miss.

U.S. Army Corps of Engineers, New England Div., Sept 1975. Notes on Cost Estimates for Ocean Dumping of Dredge Spoils 2 p.

U.S. Army Corps of Engineers, New England Division, 1978. Elutriate Testing, New London Harbor, Ct. Phase III (Sediment Analysis).

U.S. Army Corps of Engineers, New England Division, 1978. List of North Atlantic Tidal System - Sediment Characteristics.

U.S. Army Corps of Engineers, New England Division, 1978. Historical Summaries of Dredging Activities in Long Island Sound, including Amounts & Types of Material from Connecticut Harbors, Amount of Dredged Material Disposal in L.I. Sound & Dredging Permits, NEDOD-R-40.

U.S. Army Corps of Engineers, New England Division, 1978. Projects Using Long Island Sound Disposal Areas, including Federal Projects, Disposal in Long Island Sound & 4 Abstracts of Projects in the Vicinity of Long Island Sound, NEDAR-RH.

U.S. Army Corps of Engineers, New England Division, N.N., 1978. Disposal Area Monitoring System (DAMOS), First Draft Report, General Section.

U.S. Army Corps of Engineers, New England Division, 1978. "Disposal Area Monitoring System" (DAMOS) General Section Nov. 1978 Report.

U.S. Army Corps of Engineers, New England Division, January 1979 Reconnaissance Report: Dredged Material Containment in Long Island Sound, Waltham, Massachusetts. 156 p.

U.S. Army Corps of Engineers, New York District, 1977. Ocean Disposal Testing Criteria for Dredged Material, Interim Guidance, 6p.

U.S. Army Corps of Engineers, New York District and Mitre Corporation - Metrek Division, 1977. Proceedings of the New York Dredged Material Disposal Alternatives Workshop, October 11-13, 1977.

U.S. Army Corps of Engineers and New England Aquarium, December 5 & 6, 1974. Fourth Annual Ocean Disposal Conference. New England Aquarium Pavilion, Vessel Discovery Commonwealth Warf, Boston, Mass. 2 Volumes.

U.S. Army Corps of Engineers, North East Div., February 1973. Bibliography on Disposal of Dredge Spoils, Long Island Sound, Interim Memo No. COE 1. Prepared for New England River Basin Commission, Long Island Sound Regional Study, New Haven Conn. Bohlen, W.F., Devine, J., Marine Sciences Institute of Connecticut, Avery Point, Groten, Conn.

U.S. Army Corps of Engineers, San Francisco District, October 1974. Dredge Disposal Sludge San Francisco Bay & Estuary, Appendix J. Land Disposal by Rod Samuelson.

U.S. Army Corps of Engineers - Waterways Experimental Station, November 1972. Disposal of Dredge Spoil - Problem Identification and Assessment and Research Program Development prepared by Boyd, M.B., Savcier, R.T., Keeley, J.W. and others, Technical Report H-72-8, 121p. plus Figures.

U.S. Department of Agriculture, Soils Conservation Service 1973. Soils - An Interim Report. Long Island Sound Regional Study, New England River Basins Commission, New Haven, Conn.

U.S. EPA, July 1976. Quality Criteria for Water. Washington, D.C., 256 p.

U.S. EPA, 1976. Acute Toxicities of Cd 2+, Cr+6, Hg2+, Ni2+ and Zn2+ to Estuarine Macrofuana. EPA-600/J-77.

U.S. EPA, 1977. Interim Program for the Disposal of Dredged Material in Long Island Sound: A Summary States of New York & Connecticut.

U.S. EPA, (No Date). Corvallis Study Off Long Island. Application for Research Ocean Dumping Permit.

U.S. EPA, Office of Water & Hazardous Materials, June 1976. Ocean Dumping in the United States - 1976, Fourth Annual Report of the Environmental Protection Agency on Administration of Title 1 of the Marine Protection, Research, and Sanctuaries Act of 1972, 76p.

U.S. EPA, Region II, April 1974. Briefing Report - Ocean Dumping in the New York Bight Since 1973, U.S. EPA Surveillance and Analysis Div., 47p.

U.S. EPA, Region II, July 1974. Ocean Disposal in the New York Bight - Technical Briefing Report No. 1 U.S. EPA Surveillance & Analysis Division, 54p.

U.S. EPA, Region II, April 1975. Ocean Disposal in the New York Bight - Technical Briefing Report No. 2 U.S. EPA Surveillance and Analysis Division, 86p.

U.S. EPA, Environmental Research Laboratory, March 1978. Bioassay Procedures for the Ocean Disposal Permit Program. EPA - 600/0-78-010, Office of Research & Development. Gulf Breeze, Fla.

USGS, June 30, 1978. Geological Studies of the Middle Atlantic Outer Continental Shelf, Final Report - October 1, 1976 - September 1977. Prepared for Bureau of Land Management.

U.S.H.E.W. Public Health Service. Proceedings - 8th National Shellfish Sanitation Workshop, Food & Drug Administration, Shellfish Sanitation Branch, Wilt, D.S. (Editor), 158p.

U.S. Department of the Navy, Facilities Engineering Command-NESO, Oct. 1975. Navy Baseline Dredging Report, General Reference Volume, NESO 11-010, NEPSS, Port Hueneme, Ca., 34p.

U.S. Department of the Navy, December 1973. Final Environmental Impact Statement, Naval Submarine Base, New London, Groton, Connecticut. Dredge River Channel, 2 Volumes, EIS-CT-74-0077-F-1, 215p + appendix, EIS-CT-74-0077-F-2, 483p.

U.S. Department of the Navy, September 1976. Final Supplement to Final Environmental Impact Statement, Dredge River Channel, Naval Submarine Base, New London, Groton, Conn.

U.S. Department of the Navy, March 1979. Draft Environmental Impact Statement, Trident Dredging, Thames River Channel, Croton and New Canaan, Connecticut.

U.S. Naval Weather Service Command, 1970. Summary of Synoptic Meteorological Observations, North American Coastal Marine Areas, Volume 2, 633 p.

Valenti, Robert J., Peters, Stephen, 1977. Dredged Material Research Program, Aquatic Disposal Field Investigations Eatons Neck Disposal Site Long Island Sound, Appendix D: Predisposal Baseline Conditions of Demersal Fish Assemblages Technical Report D-77-6, U.S. Army Engineers Waterways Experiment Station by New York Ocean Science Laboratory.

VanVleet, E.S. and Quinn, J.G., 1977. Input and Fate of Petroleum Hydrocarbons Entering the Providence River and Upper Naragansett Bay From Wastewater Effluents, Environmental Science Technology 11:1086-1092.

Virginia Institute of Marine Science, 1967. Effects of Dredging and Dredge Spoil Disposal on the Marine Environment Special Report in Applied Marine Science and Ocean Engineering, No. 8. for U.S. Army Corp of Engineers.

Virginia Institute of Marine Science, August 1977. Middle Atlantic Outer Continental Shelf Environmental Studies. Vol. I Executive Summary. Chemical and Biological Benchmark Studies. Vol. IIA Chemical and Biological Benchmark Studies, Vol. IIB Chemical and Biological Benchmark Studies, Vol III Geologic Studies, prepared for Bureau of Land Management, Washington, D.C.

Voorhis, A.D., Webb, D.L., and Milland, R.C. July 1976. Current Structure and Mixing in the Shelf/Slope Water Front South of New England Journal of Geophysical Research Vol 81. No. 21 pp. 3695-3708.

Watson, J., 1978. Trace Metal Studies in Shellfish. A Compilation of Progress Reports: Dredging and Dumping of Spoils, Thames River, Conn., Naval Underwater Systems Center, New London, Conn.

Watson, J.K., Grillo, R.V. and Haddad, E.M., 1978. Heavy Metal Uptake In Shellfish. In: Brown, C.L., A Compilation of Progress Reports: Environmental Monitoring Program, Phase II, Dredging and Dumping Soils, Thames River, New London, Conn. Naval Underwater Systems Center, Ocean Technology Division, New London Laboratory, New London, Conn.

Weiss, D., October 1974. Late Pleistocene Stratigraphy and Paleoecology of the Lower Hudson River Estuary. Geological Society of American Bulletin, v. 85, pp. 1561-1570.

Williams,P.M. and Weiss, H.V., 1973. Mercury in the Marine Environment: Concentration in Sea Water and in a Pelagic Food Chain, J. Fish. Res. Board of Canada 30, pp. 293-295.

Williams, S.J. 1976. Geomorphology, Shallow Subbottom Structure and Sediments of the Inner New York Bight Continental Shelf Off Long Island, New York. U.S. Army Corps of Engineers. Coastal Engineering Research Center Tech. Paper 76-2, 123 p.

Williams, S.J. and Duane, D.B., 1974. Geomorphology and Sediments of the Inner New York Bight Continental Shelf. Tech. Memo 45, U.S. Army Corps of Engineers, Coastal Engineering Research Center, 81 p.

Wilson, K.W., 1970. The Toxicity of Oil Spill Dispersants to the Embryos and Larvae of Some Marine Fish. In: Proc. FAO Conference, Rome, Italy.

Wise, W.M., December 1975. The Fisheries and Fishery Resources of Long Island Sound. Thesis to Marine Sciences Research Center, State University of New York at Stony Brook, Stony Brook, New York, 122 p.

Wolff, W.J., Sandea, A.J.J. and L. deWolf, 1977. The Development of a Benthic Ecosystem Hydrobiology Vol. 52, 1., pp. 107-115.

Wood, S.A., and Folger, D.W., 1978. Submersible Observations of the Bottom in Lease Areas in the Baltimore Canyon Trough, in USGS, 1978, Geologic Studies of the Middle Atlantic Continental Shelf, Final Report, October 1976-September 1977, Office of Marine Geology, Woods Hole, Mass; Chapter 4, 15 p.

Woods Hole Oceanographic Institute and New England Division, Corps of Engineers, February 23, 1971. Proceedings, Ocean Disposal Conference. Marine Biological Laboratory in Woods Hole, Massachusetts, 17 p.

Woods Hole Oceanographic Institute and New England Division, Corps of Engineers, February 23, 1971. General problem of dredge spoil disposal (i) Biological Effects, (ii) Characteristics of Spoil Materials (iii) Criteria for Disposal Areas.

Wright, T.D., August 1978. Aquatic Dredged Material Disposal Impacts. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Technical Report DS-78-1, p. 57.

Yosso, W.E. and Hartman, E.M.J., April 1976. Beach Forms and Coastal Processes. MESA New York Bight Atlas Monograph 11, New York Sea Grant Institute, Albany, N.Y., 50 p.

Yentsch, C.S., May, 1977. Plankton Production. MESA New York Bight Atlas Monograph 12, New York Sea Grant Institute, Albany, N.Y. 25 p.

Young, R.N. and Southard, J.B., 1978. Erosion of Fine-grained Marine Sediments: Sea-floor and Laboratory experiments. Bull. Geol. Soc. of Am. Volume 89, pp. 663-672.

Zapatka, M.C. and Hann, R.W., Jr., Nov. 1977. Technical and Philosophical Aspects of Ocean Disposal. Environmental Engineering Division Civil Engineering Department, Texas A&M University, TAMV-S6-78-203.

Zapatka, T.F. and Hann, R.W., Jr., November, 1976. Evaluation of Safety Factors with Respect to Ocean Disposal of Waste Material. Environmental Engineering Division, Civil Engineering Department, Texas A&M University, 91 p.

APPENDIX A

ENVIRONMENTAL SUITABILITY ANALYSIS PROCEDURES

APPENDIX A

ENVIRONMENTAL SUITABILITY ANALYSIS PROCEDURES

This appendix describes the data sources, mapping procedures and analysis techniques used in the derivation of the environmental suitability map. The first major section discusses the source map production. Each source map is described in terms of the data it contains and how those data were transformed into map data. In some cases the source map represents a direct mapping of values found in the literature such as source map S-9, Sediment Accumulation. In more complex cases such as source map S-1, Benthic System (A), the source map is the combination of several work maps which consider subclasses or components of the source map data. Each source map description is followed by a table summarizing the references used in its preparation. A brief discussion of the data quality and coverage is also provided.

The second major section describes the development of the key derived maps which are used as issues in the study. The rationale for the combination of maps (source maps and derived maps) to produce the key derived maps is presented.

The third step in the procedure involves the use of the Delphi Technique and its use in obtaining relative importance values for the issues in this study. This approach is described in Section II.B.3. These importance values are used to "weight" the issue maps; that is, to determine the degree of importance of the various maps to arrive at suitability rankings. An overlay procedure is used to combine the weighted issue maps producing the Environmental Suitability Map.

A.1 Source Data Map Descriptions

A.1.1 Marine Ecosystem Input Factors and Criteria

The areas of concern with regard to environmental suitability for open disposal of dredged material are related to the avoidance of impacts on the following sensitive components (work maps) of the pelagic and benthic marine ecosystem:

- Valuable Habitat
- Unique Habitat
- Valuable Species
- Unique Species
- Sensitive Species

A.1.1.1 Definitions

Valuable habitat are those locations of occurrence of communities that are most valuable in providing man with products. These may include, but are not limited to shellfish beds (oyster beds are especially productive systems); banks, shoals and ledges (areas which affect fin fisheries); sand communities, particularly in Long Island Sound which generally support communities of high species diversity (also swales on the continental shelf); estuaries (areas of high community productivity which also serve as nursery areas for major finfish fisheries); and migratory pathways.

Unique habitats are locations of occurrence of communities which in the opinion of local biologists or those knowledgeable of the area that are considered biologically unique to the region. This includes areas designated for preservation (such as parks which have been considered as non-contact zones) or primary biological use, as well as those areas so designated by published opinions and conversations with authorities of the area. This would include areas which provide especially good food supplies, and unpolluted water, such as reefs, hard banks, and submarine canyons.

Valuable species are species that are important commercial and recreational species. Areas of high abundance of such species are mapped together with their associated spawning grounds and nursery areas.

Unique species are considered threatened and endangered species. Areas of occurrence or of preferred habitat of threatened and endangered species are mapped.

Sensitive species are species which may be particularly impacted by dredged disposal operations. Considerations of the occurrence of the edge of range of a species within the study area for both pelagic and benthic systems as well as the occurrence of sessile benthic species were mapped.

A.1.1.2 Benthic System Source Maps (A & B) (S1 & S2)

The benthic system consists of the combined total of two source maps (A&B). The relative importance of the component work maps for A&B source maps is as follows:

Map	Importance Factor
Source Map A	
1. Sensitive Species Work Map	2x
2. Valuable Habitat Work Map	2x
Source Map B	
3. Unique Habitat Work Map	1x
4. Valuable Species Work Map	3x
5. Unique Species Work Map	1x

The valuable species input includes spawning and nursery areas of the benthic system and has been considered three times as important as unique species and unique habitat inputs due to the significance of potential impacts on these life stages and on the subsequent short-term structure of the community of an area. In addition, the use of a disposal area near productive shellfish beds could cause long-term depletion of stocks. Sensitive species and valuable habitat were given importance factors of twice those of unique habitat and unique species. This reflects the potential effects resulting from limitations on the edge of range of species and from disposal on areas where benthic species lack motility to avoid disposal impacts and the significance of potential loss of valuable species such as shellfish beds.

A.1.1.2.1 Valuable Benthic Habitat Work Map

The following benthic habitats are considered valuable:

- Shellfish and oyster beds
- Banks, ledges and shoals
- Estuaries
- Long Island Sound sand communities
- Swales (In ridge and swale morphology on continental shelf)

Shellfish and oyster beds are productive systems. Banks, ledges and shoals are generally areas of high productivity which affect fin fisheries. Sand communities, particularly in Long Island Sound, generally support communities of high species diversity. This is also true of the low swale areas on the continental shelf where the rolling ridge and swale morphology is present. Estuaries are areas of high community productivity and nursery areas for major finfish fisheries. Estuary influences were mapped as the shallow near-shore areas (less than 15 feet deep) within the Sound.

Criteria	Sensitivity Rating
Four or more of the above communities present	5
Two or three of the above communities present	4
One of the above communities present	3
None of the above communities present	1

Disturbance in any of these habitats can result in fluctuations in species composition and abundance and could directly affect their utilization by valuable fish species and their importance to man as a resource. Areas of Long Island Sound where sand is 90% or greater of the sediment were plotted as valuable habitat since it is assumed the dredged material will be mud and the placement of mud on sand is more likely to have short-term negative impacts than mud on mud.

A.1.1.2.2 Unique Benthic Habitat Work Map

Federal, State and local parks, areas of high species diversity and features such as swales, reefs or canyons are considered unique benthic habitats.

Criteria	Sensitivity Rating	Sensitivity Rating	Sensitivity Rating
Federal, State or local parks	6	-	-
Areas with species diversity		Within swale, reef, or canyon heads	Within an Interim Dump Site
Greater than 4.5	5	6	3
4.2 - 4.49	4	5	2
2.4 - 4.19	3	4	1
1.5 - 2.39	2	3	
Less than 1.5	1	2	

For parks, a zone 1 km from shore was included. Diversity indices were also used for relating community health and stability. VIMS (1977) reported benthic species diversity to increase from shore with highest diversity on the shelf break and upper slope for the Mid-Atlantic area. Water depths here were 100-200 meters in the shelf break and greater than 200 meters in the upper slope. From the VIMS results diversity indices were extrapolated for 5 cross-shelf zones in the study area. They reported no north/south variability in benthic diversity in the mid-Atlantic. One hundred and forty-four (144) data points in the 5 depth zones were averaged for each zone and this average used as the basis for diversity in each cross-shelf zone. Variability in each zone also was used in determining the rating for each zone. A total of 143 stations in Long Island Sound taken by NMFS SHL were used to contour zones of diversity. These zones (three in Long Island Sound, high, moderate, low) were averaged to get the rating for each of the zones. Swale areas on the shelf were given a +1 when obvious on bathymetric charts, since VIMS identified swales as areas which support communities of high diversity. The parameters governing species composition in swales are; presence of silty sands (about 10% organic fines plus shelly material) and fairly constant temperature. Holes and depressions were not included since they do not show these characteristics. Hard bank (reefs) and canyon heads were also considered here since they serve as especially favorable habitat for many valuable species of fish and shellfish.

Interim dump sites in Long Island Sound received a -2 from the respective diversity rating. These active sites are occasionally under stress and probably have opportunistic communities dominating. Dumping in such a pre-stressed area would have much less of a detrimental impact than it would in another area with a similar diversity.

A.1.1.2.3 Valuable Benthic Species Work Map

Areas of known spawning or seasonal distribution during spawning of the major species were mapped. This included overall distribution of the sessile shellfish as well as the general distribution of the lobster. These distributions were overlayed and the number of species were plotted.

The following fish and shellfish were plotted and used in this site selection process. Their use here was determined by their importance to the recreational and commercial fisheries in the study area as well as the data availability for such a siting study.

Pelagic	Benthic
White Hake	Summer Flounder
Red Hake	Yellowtail Flounder
Bluefish	Winter Flounder
Mackerel	Lobster
Butterfish	Tilefish
Striped Bass	American Plaice
Scup	Quahog - Ocean/Bay
Squid	Scallop - Ocean/Bay
Atlantic Cod	Surf Clam
Silver Hake	Black Sea Bass
Menhaden	Oysters
Alewife	
Atlantic Herring	
Weakfish	
Dogfish	

These species were also considered in the development of the Fisheries Source Map. The criteria and rating for the valuable benthic species is as follows:

Criteria	Sensitivity Rating	Sensitivity Rating (with nursery area of one or more species)
Spawning grounds of demersal fish; and locations of shellfish species		
7 or more species total	5	6
5 - 6 species	4	4
3 - 4 species	3	4
1 - 2 species	1	2

A.1.1.2.4 Unique Benthic Species Work Map

There is no occurrence of unique species in the form of threatened and endangered species. Thus the suitability rating for the study area for this work map is 1.

A.1.1.2.5 Sensitive Benthic Species Work Map

The edge of range and motility of species were mapped as follows:

Criteria	Sensitivity Rating
Presence of 4 or more sessile species	5
2 - 3 sessile species	4
1 sessile species or 4 valuable species near extremity of range	3
2 - 3 valuable species near extremity of range	2
0 - 1 valuable species near extremity of range	1

A.1.1.2.6 *Data Coverage and Sources*

For many parameters, useful site-specific information was not available for mapping. Therefore much of the mapping of the distribution of various species was based on regional data which provided information on distribution by season, annual distribution, north-south, east-west limits, depth salinity and temperature requirements etc. which was fairly useful for describing typical distribution. It is however realized that given different environmental concerns the species (isolated or in mass) mapped may appear outside of the limits mapped. This regional type of data, some of which was rather site specific, was taken from TRIGOM (1974); Gusey (1977); Saila (1973); BLM (1978, 1977 and 1976); NJDEP (1975); Olsen and Stevenson (1975); Connecticut DEP (1977) and Sissenwine (1974).

Other data was extrapolated over areas where the extent of our knowledge of such data was allowed. This included data from VIMS (1977) and Radosh et al., (1978).

Rather site specific data was taken on species diversity within Long Island Sound however due to the variability in replicate samples, sample size, etc., the data was used cautiously as it applied to the ecosystem model. This data included McCall (1977); MACFC (1974) as well as Damos data and Rhoads data at existing dump sites.

Much of the site specific data on locations of important fishing areas NERBC (1975); McHugh (1977); NAVFAC (1976); Freeman and Walford (1974) and Connecticut DEP (1977) fishing areas were considered fairly accurate as data sources, for that purpose.

GUSEY, 1977
TRIGOM, 1974
Saila, 1973
Radosh et al., 1978
Bureau of Land Management, 1978, 1979
NERBC, 1975 February
NJDEP, 1975
Ropes and Chang, 1977 (NOAA/NMFS)
Olson and Stevenson, 1975
Conn DEP, 1977
Wise, 1975
Sissenwine, 1974
Freeman & Walford, 1974
Virginia Institute of Marine Science, 1974
McCall, 1977
Richards, 1963
Serafy, Hartyband, and Bowen, 1977
NAVFAC, 1976
Valenti and Peters, 1977
Frany, 1976
Williams, 1976
NERBC, 1975
MACFC, 1974 (NOAA, NMFS, SHC)
Short-Nose Sturgeon Recovery Team, 1977
Rhoads, 1972; 1973a; 1973b, 1973d; 1973e; 1974a; b; c;

Rhoads, Aller, and Goldhaber, 1975
McHugh, 1977
McHugh and Ginter, 1978
William, Davis, and Wennemer, 1977
Carey, 1967
TRIGOM, 1976
Clark
Grassle et al., 1975
Haedrick, Rowe, and Pollonic, 1975
Uzmann et al., 1977
Wigley, Theroux, and Murray, 1975
Haefner and Musick, 1974
BLM, 1976, 1977

A.1.1.3 Pelagic System Source Map (S3)

The relative importance of the component work maps which comprise the pelagic system source map are as follows:

Map	Importance Factor
1. Valuable Species Work Map	3x
2. Unique Species Work Map	2x
3. Sensitive Species Work Map	1x
4. Valuable Habitat Work Map	1x
5. Unique Habitat Work Map	1x

A.1.1.3.1 Valuable Pelagic Habitat Work Map

No specific valuable pelagic habitats occur in the study area. Constricted migratory pathways were evaluated as a possible pelagic valuable habitat. However, constrictions of migration within the region are too wide to represent realistic constrictions, considering the size of possible disposal plumes. Thus, the study area was rated 1 for this work map.

A.1.1.3.2 Unique Pelagic Habitat Work Map

No unique habitats were identified for the pelagic system. Thus the area was rated 1 for this work map.

A.1.1.3.3 Valuable Pelagic Species Work Map

Spawning grounds of valuable species were rated as follows:

Criteria	Sensitivity Rating	Sensitivity Rating (With nursery area of one or more species)
Spawning grounds for 6 or more valuable species	5	6
4 - 5 species	4	5
2 - 3 species	3	4
1 specie	2	3
none	1	2

A.1.1.3.4 Unique Pelagic Species Work Map

The occurrence of threatened and endangered mammals, turtles and the shortnose sturgeon was mapped as follows:

Criteria Number of threatened and endangered species	Sensitivity Rating
5 species	3
one to 5 species	2
none	1

A.1.1.3.5 Sensitive Pelagic Species Work Map

The sensitivity of the edge of range of pelagic species was mapped as follows:

Criteria Number of species near extremity of range	Sensitivity Rating
7 - 14 species	3
3 - 6 species	2
0 - 2 species	1

A.1.1.3.6 References.

References used for Map S3 are listed in Section A.1.1.2.6.

A.1.2 <u>Water Quality Source Map (S4)</u>

The critical parameters affecting the assimilative capacity of a potential disposal site include:

1) dissolved oxygen concentrations
2) nutrient concentrations
3) turbidity - suspended sediment and particulate concentrations
4) municipal and industrial wastewater loading
5) microbial status

The microbial status is largely a function of the contaminant (especially municipal wastewater) loading. Therefore, it is believed that a contaminant loading map would contain the necessary ratings which would encompass microbial status. The work map development includes, therefore, only the first four data categories.

Data used in the work maps are representative of conditions during periods of maxium stress, namely July-September for nutrients and dissolved oxygen and November-June for suspended sediment concentrations.

Work maps and their criteria include:

1) Dissolved oxygen - summer season, near bottom dissolved oxygen expressed as a percent of saturation.

Criteria	Sensitivity Value
More than 80%	1
70% - 80%	2
60% - 70%	3
Less than 60%	4

2) Nutrient concentrations - combined effects of summer season phosphorus, NO_3-N, NO_2-N, NH_3-N nutrients expressed in micrograms/liter.

Nutrient	Criteria (in micrograms per liter)	Sensitivity Rating
Soluble Phosphorus	less than 0.2	1
	0.2 - 0.4	2
	0.4 - 1.0	3
	greater than 1.0	4
NO_3-N	less than 1.0	1
	1.0 - 5.0	2
	5.0 - 10.0	3
	greater than 10.0	4
NO_2-N	less than 0.05	1
	0.05 - 0.1	2
	0.1 - 0.3	3
	greater than 0.3	4
NH_3-N	less than 1.0	1
	1.0 - 5.0	2
	5.0 - 20.0	3
	greater than 20.0	4

A total nutrient level map was prepared from consideration of the four nutrient maps described above. The values assigned to this map are based on the sum of the values from each of the component maps as shown below.

Total Nutrients

Criteria	Sensitivity Rating
Less than 6	1
6 - 10	2
10 - 14	3
More than 14	4

3) Suspended Particulate Concentrations

Criteria (in micrograms/liter)	Sensitivity Rating
Less than 250	1
250 - 1000	2
1000 - 10,000	3
More than 10,000	4

4) Municipal and industrial waste loading-areas effected by municipal and industrial waste discharges expressed in discharge quantities of million gallons per day (MGD).

Criteria (in MGD)	Sensitivity Rating
No contaminant loading	0
Less than 50	1
50 - 200	2
200 - 500	3
More than 500	4

The water quality source map is derived from a combination of the four water quality work maps. The importance factors used to weight the maps relative to each other are:

Work Map	Importance Factor
Dissolved Oxygen	4x
Total Nutrients	3x
Contaminant Loading	2x
Suspended Sediment	1x

The values for the water quality source map show the relative degree of water quality deterioration (high values represent poor water quality). These values are:

Criteria	Sensitivity *Rating*
Water Quality Total Rating Of:	
10 - 12	1
13 - 15	2
16 - 18	3
19 - 21	4
22 - 24	5
25 - 27	6
28 - 30	7
31 - 33	8
34 - 36	9
More than 37	10

Data Coverage and Sources

Inputs to the water quality source map include:

1) Dissolved oxygen level
2) Nutrients
3) Contaminant loading
4) Suspended matter

Dissolved Oxygen Level

In the Long Island Sound area, data on near-bottom dissolved oxygen levels are available at some 28 locations (August, 1971 Cruise). In general, data coverage in this area is good.

On the continental shelf region, good data coverage on dissolved oxygen levels is available from MESA, New York Bight Hydrographic study (NOAA, 1977).

In Block Island Sound coverage is lacking. Extrapolations are made from data inside Long Island Sound and on the continental shelf side to cover this area.

Nutrients

This work map combines the inputs from form nutrient components NH_3, NO_2, NO_3 and P.

There is food data coverage from the MESA, New York Bight Hydrographic Study on the continental shelf area of New York Bight (NOAA, 1977).

In Long Island Sound, Hardy's 1971 study on Movement and Quality of Long Island Sound Waters and Environmental Baselines in Long Island Sound from the Mid-Atlantic Coastal Fisheries Center Ecosystem Investigation (NOAA, 1974), together with Bowman's (1977) study on The Nutrient Distribution and Transport Along An East-West Transect Extending From Western Long Island to the Race, provide good data coverage in Long Island Sound.

In Block Island Sound limited data are available from a study on The Estaurine and Coastal Oceanography of Block Island and Adjacent New York Coastal Waters conducted by the New York Oceanographic Study Laboratory in 1974. Inference is made for mapping purposes from limited data available in this area and those inside Long Island Sound and on the continental shelf region.

Contaminant Loading

This component considers the contaminant loadings from industrial and municipal sources into coastal waters. The extent of influence from these loadings is estimated by the extent of tidal excursion. Generally, good data coverage is available from information provided by the EPA water quality plans and NOAA study on Contaminant Input to the New York Bight (NOAA, 1976).

Suspended Matter

Site-specific data on suspended matter levels are generally lacking. Bohlen's 1974 investigation on suspended matter concentrations in Eastern Long Island Sound is restricted to an area extending from Connecticut River to Fishers Island. Other information available include the Riley (1959) study on suspended matter in Central Long Island Sound, and general description on the suspended matter level by Shen and Riley (1959). Interpolation has been made from these available data on the spatial variations of suspended matter in the study area.

Conn DEP, 1976
Bohlen, 1974
Hardy, 1972
Alexander and Alexander, 1977
O'Connor, Thomann, and Salas, 1977
NOAA, 1974
NYOSL, 1974
Mueller and Anderson, 1978
USEPA, States of Connecticut and New York, 1975
State of Rhode Island, 1972
Bowman, 1977
Bowman and Weyl, 1972
Riley, 1959
NOAA, 1976
ASCE, 1975
Manheim, Meade, and Bond, 1970
NOAA, 1977

A.1.3 Water Column Stratification Source Map (S-5)

This source map depicts the intensity and characteristics of water column stratification. Stratification intensity varies seasonally and it is strongest in summer season. It is important since a stratified water column tends to affect the current regime and water quality assimilative capacity.

The intensity of vertical water column stratification is measured by the steepness of the summer season density gradient, $\Delta\sigma_T/M$ where,

$\Delta\sigma_T$ = change of density σ_T in the vertical direction

$\sigma_T = (\rho - 1) \times 10^3$, - Density in gm/cm^3

for $\Delta\sigma_T/M \leq 0.05$ weak stratification

$0.05 \leq \Delta\sigma_T/M \leq 0.09$ mild stratification

$\Delta\sigma_T/M > 0.1$ strong stratification

Characteristics of water column stratification describe the following, stratification phenomena:

- o Near-surface, mid or near-bottom stratification.
- o Permanent near-bottom shelf cold pool.
- o Shelf/slope water mass front

Combining the intensity and characteristics, the following criteria of stratification characteristics are derived:

Criteria	Sensitivity Rating
Weak stratification (entire water column)	1
Mild stratification (entire water column)	2
Strong stratification at near-bottom layer	3
Strong stratification at mid-depth layer	4
Strong stratification at near-surface layer	5
Shelf/slope water front	6
Strong stratification (entire column)	7
Strong surface layer stratification with bottom (cold pool)	8

As observed from the above, the numerical values assigned tend to increase with increasing degrees of stratification and increasing adverse effects on water column assimilative capacity towards the upper surface layer. However, categories 7 and 8 both describe strong stratification throughout the water column and rating 8 implies more unfavorable conditions in water column assimilation capacity at near-bottom water.

Data Coverage and Sources

In the mid-to-deep water depths from Western Long Island Sound to the Race, vertical density profiles are available at some 16 locations (April 1971, cruise data) and at locations (August 1971, cruise data) along an east-west transect in water depths ranging generally from 15 to 30 meters or deeper. Data are also available at two north-south transects in Central Long Island Sound. Gordon and Pilbeam (1975) discussed the salinity gradient and mixing in the Central Long Island Sound. Salinity data are available on a north-south transect and an east-west transect in this area in general. There is good data coverage for assessing water column stratification conditions in water depths deeper than 15 meters from Western Long Island Sound to the Race. More data points are available in Central Long Island Sound region covering near-shore areas with water depths of approximately 9 to 10 meters.

In shallow coastal water depths less than 10 meters, stratification conditions are inferred from the discussion of Gordon, Pilbeam (1975) and Gordon and Bokuniewicz (1977) on mixing conditions and salinity gradient in near-shore areas of Long Island Sound.

Generally, the data coverage for these shallow regions is poor. However, Gordon and Pilbeam have studied the salinity gradient along a north-south transect in Central Long Island Sound.

In the region east of the Race extending southward towards the eastern zone of Long Island, stratification conditions are inferred from the persistent two-layer estuarine circulation pattern and the conditions in the offshore New York Bight area.

Generally, in Block Island Sound, data coverage is lacking. Stratification conditions are inferred from those conditions in the Eastern Long Island and in the offshore New York Bight Area. Cruise data from such investigations as Scott, Csanady (1975), Ketchum, Corwin (1957), ICNAF Cruise (1967) give good coverage of salinity conditions in the offshore New York Bight Area.

TRIGOM, 1974
Hardy, 1972
Bowman and Weyl, 1972
Gordon, Amos, and Gerard, 1974
Ketchum and Corwin, 1965
Gordon and Pilbeam, 1975
Scott and Csanady, 1976
Bowman and Wunderlich, 1977

A.1.4 Dynamic Characteristics Source Map (S6)

Dynamic characteristics measure the strength of the current regime in the vertical water column and therefore, it is a measure of flushing capacity. It is noted that the current regime in Long Island Sound is largely tidal-driven with modifications due to winds and fresh water discharge resulting in an "estuarine two layer circulation".

On the shelf side south of Long Island, meteorological forcing mechanisms become more important. A general geostrophically-driven SW surface mean flow is observed over most parts of the continental shelf water with current magnitudes increasing to approximately 10 to 13 cm/sec towards deeper water near the 100 meter contour. Towards the shore, currents are observed to fluctuate with tidal frequency implying stronger tidal effects on the current regime as the shoreline is approached.

Hence, flushing strength is mainly tidal-driven inside Long Island Sound and geostrophic meteorological-driven (mean drift) on the shelf side with a transition zone from mean drift to tidal-driven in nearshore areas outside of the Sound.

The dynamic characteristics of an area are measured by the intensity of predominant current regime. Inside Long Island Sound, the average tidal speed, that is the root-mean-square speed which gives the magnitude of kinetic energy over one tidal cycle, is used. On the shelf side, mean current velocity is employed. It should be made clear that surface layer current velocities are considered in this issue as we are interested in the effects of surface currents, coupled by water column stratification on flushing and water column waste assimilative capacity. The following criteria are used to describe the ranking in the dynamic characteristics source map:

Criteria (current magnitude in cm/sec)	Sensitivity Rating
less than 10	1
10 - 20	2
20 - 30	3
30 - 40	4
40 - 50	5
50 - 60	6
60 - 70	7
70 - 80	8
80 - 90	9
greater than 90	10

Data Coverage and Sources

The dominant current regime in Long Island Sound and Block Island Sound is largely tidally-driven superimposed by modifications due to winds and fresh water discharge.

The R.M.S. (root-mean-square) tidal speed is used in mapping. This measures the intensity of the kinetic energy over one tidal cycle. Input to the physical term, (r.m.s.) tidal speed is the surface tidal current data available from tidal current chart of Long Island Sound and Block Island Sound (National Oceanic Survey). Good data coverage exists in Long Island Sound. For areas east of Block Island in Block Island Sound, the dynamic characteristics are inferred from the data near Block Island. There is good data coverage for several areas covering the candidate site in Long Island Sound.

On the continental shelf, dynamic characteristics are inferred from the dominant geostrophically-driven currents. Mean current data are used. Tidal influence becomes more important approaching the southern coast of Long Island. Beardsley, Boicourt and Hansen (1976), and Beardsley and Butman (1974) discussed the circulation patterns on the continental shelf of the New York Bight. Scott and Csanady (1976) studied the nearshore currents off Long Island. The results of their studies were used in the data mapping.

USEPA, Region II, 1978
Bradley, Boicourt, and Hansen, 1976
Beardsley and Butman, 1974
NOAA, 1977
Scott and Csanady, 1976
Riley, 1952

A.1.5 Bathymetry (S7)

This source map also serves as the study area base map. Bathymetric contours are taken off the NOAA Bathymetric Charts. Actual water depths are stored in the computer without value assignment.

Data Coverage and Sources

Published NOAA maps:

Long Island Sound
Block Island Sound
Continental Shelf
Continental Shelf Slope off Long Island

A.1.6 Bottom Energy Source Map (S8)

This source map measures the potential for resuspension of bottom materials due to the following forcing mechanisms:

1. Bottom Tidal Velocity
2. Bottom Wind-Drive Current
3. Bottom Wave-Induced Orbital Velocity
4. Breaking and Shoaling Internal Waves

All of the above mechanisms are important for bottom material resuspension. Tidal velocity fluctuates periodically and it has the highest frequency due to its daily nature. Wind-driven currents will be considered as a less frequent forcing mechanism than tidal action because of lower frequency of occurrence of major events and because it takes a certain time for a surface wind stress to transfer its momentum to the bottom water. A sufficiently large surface wind stress is required which may not occur every day. Bottom wave-induced orbital velocity resulting from surface gravity waves driven by a surface stress over a sufficiently long duration is considered less frequent and hence a superimposing resuspension forcing agent to more frequent tidal and wind-driven effects. Fetch-limited wave generation inside Long Island Sound and deep waters on the continental shelf are expected to result in low bottom orbital wave velocity. The breaking and shoaling internal waves occur near 35 m to 50 m contours. Internal waves are generated near the shelf break in summer stratified water. Hence, its frequency of occurrence is the lowest and it is therefore considered as a superimposing mechanism on the more frequent wave action. The method of measuring resuspension capacity due to the above mechanisms are summarized below.

A.1.6.1 Bottom Tidal Velocity Work Map

Near bottom peak tidal velocity is estimated from generalized vertical velocity profiles and the tidal velocity recorded by current meters at certain distances above the bottom. It is assumed that this peak tidal velocity will reflect the strength of the bottom tidal velocity over a certain portion of time within the tidal cycle. From published sources of investigations of velocity for initiating movements of bottom material, it was found that this bottom velocity varies as the organic content which affects the cohesiveness of the material. Probability of resuspension increase with increasing rating. The following ranking scheme was used:

Criteria (cm/sec)	Sensitivity Rating
less than 10	1
10 - 20	2
20 - 40	3
40 - 60	4
60 - 80	5
greater than 80	6

A.1.6.2 Wind-Driven Bottom Current Work Maps

Monthly mean scalar wind speed over the continental shelf is employed. In general, wind velocity varies from 10 knots to 18 knots. A scheme is developed to rank the wind stress which is proportional to $(\text{speed})^2$ for each month.

Criteria (wind speed)	Sensitivity Rating
10 - 12 knots	1
12 - 14 knots	2
14 - 16 knots	3
16 - 18 knots	4
greater than 18 knots	5

For each month, the study area is ranked and a yearly average is computed by the following:

$$\text{Yearly Average} = \sum_{1}^{12} \frac{\text{Rank x (\# of months)}}{12}$$

A scheme is then set up to measure the combined effects of water depth and yearly average wind stress. It is noted that the bottom wind-driven currents are not actually estimated. Therefore, from the ranking scheme, a higher rank implies a higher probability of generating a significant wind-driven bottom current for resuspension of bottom material.

	Wind-Driven Bottom Current Work Map Values				
Yearly Avg. Rank / Depth in fathoms	less than 1.2	1.2 to 1.5	1.5 to 2.0	2.0 to 2.5	greater than 2.5
Greater than or Equal to 100	0	0	0	1	1
50 - 100	1	1	2	2	3
25 - 50	2	2	3	4	5
10 - 25	3	4	5	6	7
Less than 10	5	6	7	8	8

A.1.6.3 Wave Orbital Velocity Work Map

Wave action is treated in the similar manner as the wind stress effect. The yearly average frequency of occurrence of waves greater than 3.5 meters (which represents a wave with typical wave period of about 9 secs within the areas used). A ranking scheme is employed for frequency ranges of waves exceeding 3.5 meters.

Criteria (% waves greater than 3.5 meters)	Sensitivity Rating
0 - 4%	1
5 - 9%	2
10 - 15%	3
greater than 15%	4

$$\text{Yearly Average} = \sum_{1}^{12} \frac{\text{Rank x (\# of months)}}{12}$$

The bottom orbital velocity is then estimated for this wave and the following ranking scheme is developed.

Bottom Wave Orbital Velocity Work Map Values

Bottom Velocity (Yearly Average)	Less than 10 cm/sec	10-20 cm/sec	20-30 cm/sec	30-45 cm/sec	Greater than 45 cm/sec
1.0 - 1.25	0	1	3	5	6
1.25 - 1.50	1	2	4	5	7
1.5 - 2.25	2	3	5	6	8
2.25 - 2.75	3	4	6	7	9
Greater than 2.75	4	5	7	8	10

Fetch-limitations in Long Island Sound necessitate an effective fetch wave generation calculation. Wave heights and subsequent bottom orbital velocities were estimated using this method.

The breaking and shoaling internal waves can be an important contributing resuspension mechanism in water from 35 m to 50 m in depth.

Tidal resuspension potential is developed by superimposing effects of wind stress and wave action. Hence, bottom energy of an area increases with increasing potential of tidal resuspension. Wind-driven currents which are more predominant in shallow water, are then superimposed on tidal potential. Finally, wave orbital velocity induced by a surface wave of 3.5 meters as well as breaking and shoaling internal waves are then superimposed.

The values from each of the three work maps, bottom tidal velocity, wind-driven bottom currents and wave orbital velocity, are combined into low (L), medium (M) and high (H) groups as shown in the table below to arrive at the sensitivity values for the bottom energy source map.

Bottom Energy Work Map Combination

Tidal Currents	Wind Driven Currents	Waves and Internal Waves	Sensitivity Value
H (5,6)	H (5,6)	H (5,6)	10
		M (3,4)	
		L (0,1,2)	
	M (3,4)	H (5,6)	9
		M (3,4)	
		L (0,1,2)	
	L (0,1,2)	H (5,6)	8
		M (3,4)	
		L (0,1,2)	
M (3,4)	H (5,6)	H (5,6)	7
		M (3,4)	
		L (0,1,2)	
	M (3,4)	H (5,6)	6
		M (3,4)	
		L (0,1,2)	5
	L (0,1,2)	H (5,6)	
		M (3,4)	
		L (0,1,2)	4
L (1,2)	H (5,6)	H (5,6)	
		M (3,4)	
		L (0,1,2)	3
	M (3,4)	H (5,6)	
		M (3,4)	
	L(0,1,2)	L (0,1,2)	2
		H (5,6)	
		M (3,4)	1
		L (0,1,2)	

Data Coverage and Sources

Inputs to this source map include:

1) Near Bottom Tidal Velocity
2) Near Bottom Wind-Driven Currents
3) Near Bottom Wave-Induced Orbital Velocity
4) Breaking and Shoaling Internal Waves

Near Bottom Tidal Velocity

This data is presented from generalized vertical tidal velocity profiles and the tidal velocity recorded by current meters at a certain distance above the bottom. Vertical velocity profiles are available at locations in Central Long Island Sound and Eastern Long Island Sound from studies by Bokuniewicz and Gordon (1977) near the disposal sites at Eatons Neck and New Haven. In Eastern Long Island Sound, Riley (1953) studied the vertical tidal velocity profile at a site located in a water depth of approximately 35 meters. Velocity profile data are also available at the Cornfield Shoals Disposal Site in Eastern Long Island Sound. Tidal velocity data covering the entire Long Island Sound and Block Island Sound are available from the tidal current charts of this area published by National Oceanic Survey.

At offshore areas on the continental shelf, Butman and Noble (1976) and Butman, Noble and Folger (1977) have studied the near-bottom currents and the associated bottom sediment mobility in the offshore New York Bight Area. Scott and Csanady (1975) studied the current regime near the southern coast of Long Island. Their findings and discussions were used for interpretation of the near-bottom tidal behavior in this area. The strength of the tidal velocity on the continental shelf is generally weaker than that inside Long Island Sound.

Near Bottom Wind-Induced Currents

This measures the combined effect of surface wind stress, which is related to the surface wind speed and the water depth on reresuspension of bottom materials.

Good coverage on surface wind speed is available for the offshore New York Bight area from the MESA, New York Bight Hydrographic study (NOAA, 1977). The water depths are readily available from bathymetric maps.

Long Island Sound and Block Island Sound data on over-water wind speed are not readily available. However, wind speed data are available for some coastal locations. The effect of wind-induced currents is therefore interpretated from these wind speeds, with considerations of land effects of Connecticut and Long Island. At Block Island Sound, interpretation has been made from data available in the overlapping region of Block Island Sound and the New York Bight.

Near-Bottom Wave-Induced Orbital Velocity

This measures the effect of wave-induced orbital velocity on bottom resuspension. Data on near-bottom wave-induced velocities in the study area are not available. Interpretation of the estimated near bottom wave orbital velocity has been made in the mapping process.

Good data coverage for frequency of surface wave height more than or equal to 3.5 meter is available from the MESA, New York Bight study (NOAA, 1977). The bottom wave-induced orbital velocity of this wave is estimated. The combined effect of the frequency of exceedance of this wave height and its associated magnitude of the near-bottom wave velocity is used for interpretation of their impacts on bottom-resuspension for the mapping procedure.

Long Island Sound and Block Island Sound is sheltered by Long Island on the south and the Mainland on the north. Wave-induced velocity is estimated from the seasonal maximum wind velocities over this area considering limitations on fetch distance, friction of the land mass, and the effects of water depths. The estimated wave-induced velocity is then used for the mapping procedures. The breaking and shoaling internal waves are considered to be important re-suspension mechanism in water depths from 35 to 50 meters on the continental shelf.

NOAA, 1977
Bokuniewicz et al., 1977
Butman and Noble, 1978
Butman, Noble, and Folger, 1977
Bokuniewicz and Gordon, 1977
Damos, 1978
Lettali, Brower, and Quayle, 1976
Leendertse and Liu, 1971

A.1.7 Sediment Accumulation Source Map (S-9)

This source map depicts the net rate of sediment accumulation in terms of grams/meter^2/year over the study area. The map is used in conjunction with the bottom energy source map (S-8) for the evaluation of the containment capabilities of the potential sites. The map is classified as follows:

Criteria Average rate of sediment accumulation ($g/m^2/yr$)	Value
0	0
200	2
400	4
600	6
800	8
1,000	10

Data Coverage and Sources

Bokuniewicz and Gordon, 1977 studied the effects of storms on the stability and fate of dredged materials in subaqueous disposal sites. They rated the silt accumulation covering most parts of Long Island Sound from Eatons Neck to the eastern end of the Sound. Data is not available for the Western Long Island Sound Area. For the Block Island Sound, interpretation from available data inside Long Island Sound has been made for in mapping. Several references such as Emery and Uchupi (1972) indicate that sediment accumulations on the continental shelf are nil because of the sediment trapping efficiency of Long Island Sound.

Bokuniewicz and Gordon, 1977
Emery and Uchupi, 1972

A.1.8 Fisheries and Shellfisheries (Species Distributions) (S-10)

The distribution of the most common commercial and recreational fish species were plotted throughout the study area. A total of 14 and 8 species were used for the pelagic and benthic realms respectively. The ratings for the number of species are as follows:

Benthic Work Map

Criteria No. Species Present:	Sensitivity Rating
7 - 8	5
5 - 6	4
4	3
2 - 3	2
1	1

Pelagic Work Map

Criteria No. Species Present:	Sensitivity Rating
13 - 14	5
9 - 12	4
6 - 8	3
3 - 5	2
1 - 2	1

Benthic species were rated more sensitive due to their bottom habitats and catch techniques.

The ratings of the benthic and pelagic species distribution was summed equally to give the species distribution source map.

Data Coverage and Sources

See Section A.1.1.2.6.

A.1.9 Fisheries and Shellfisheries (Fishing Grounds) (S-11)

This map was developed by utilizing catch data summarized by the International Commission for the Northwest Atlantic Fisheries (ICNAF) and other fishing data in the project area. The ICNAF has two zones which are partly located in the study area. Zone 6A is somewhat west of 5ZW both offshore New Jersey and both having similar depths. The ICNAF compiles catches of food finfish, industrial and semi-industrial species.

Most (85%) of the 5ZW landings were from pelagic species (Atlantic herring, Atlantic squid and hakes) whereas half the landings in 6A were shellfish and demersal finfish. Benthic landings in zone 6A exceeded these in 5ZW by nearly 4 to 1. Zone 5ZW was considered twice as sensitive as zone 6A.

Zones 6A and 5ZW therefore were given a 2 and 1, respectively to equivocate the ICNAF data with other inshore data. This other data consisted of:

1) zones of heavy and moderate trawling;
2) species specific fisheries within Long Island Sound;
3) lobstering areas (Long Island Sound);
4) shellfish beds; and
5) fishing banks, ledges and shoals (areas which usually support favorable densities of recreationally and commercially important fish).

The criteria and rating are as follows:

Criteria	Sensitivity Rating
Shellfish abundance very high and 1 or 2 other shellfish abundant	5
Shellfish abundance very high or 3 abundant species	4
Shellfish abundance high or 2 species abundant	3
Shellfish abundance high or 1 specie	2
Other	1

The following were summed for other areas as follows:

Lobster fishery (Long Island Sound and Block Island Sound only)	2
Shellfish beds (each species)	2
Fishing banks, ledges, shoals	2
Flounder fishery, other trawl fishery, pound net fishery (each)	2
Scup, Menhaden and Connecticut River, shad and alewife fishery (each)	1
Heavily trawled areas	2
Moderately trawled areas	1

The heavily trawled and moderately trawled areas were considered to be equivalent to zones 6A and 5ZW respectively and gave a base to the map. To this base the other criteria were used and added as the base to arrive at numerical ratings for the Fishing Grounds source map. Known areas typical of heavy catches were considered and plotted as "very high abundance". "Abundant species" was used as an indication of a typical catch slightly greater than commercially feasible. These catches varied by species. This overlying of different species along with the catch and trawl activity data as well as the map on species distribution identified zones of great or potentially great usage as a fishery.

Data Coverage and Sources

See Section A.1.1.2.6.

A.1.10 Resources and Uses (S-12, S-13, S-14)

The resources and used source map consists of three maps which cover point, linear and area data types. The criteria for classifying data in this source map series are listed below.

Criteria	Sensitivity Rating
Areas representing dangers to dumping	9
Obstructions Shipwrecks in shallow water Shoals, reefs and rocks Unexploded objects or ordinance Explosive dumping areas Military exercise areas (anti-submarine warfare tactics and surface gunnery - Zone 5)	
Sensitive Shoreline Use	8
Beaches Federal & State Recreation areas Proposed heritage areas Major recreational ports Vistas Marina facilities Open space areas	
Uses subject to damage as a result of dumping	8
Submarine cables Pipelines	
Cultural Resources Subject to Burial/Damage	7
Areas of archaeological value Shipwrecks	
Surface Uses Subject to High Level of Interference	7
Major fishing ports Major commercial ports Converging or restricted navigational areas Precautionary areas (navigational) Offshore navigational lanes Restricted anchorages	
Use areas Subject to High Level of Disruption	7
Shallow navigational channels Boating and sport fishing areas Conservation areas Fishing pier areas Fish trap areas Fishing structures Scientific research areas	

Surface Uses Subject to Moderate Levels of Interference	6

Military use (individual steaming exercise areas - Zone 1)
Military use (general air and surface operations plus ASW Training - Zone 2)
Military use (submarine and ASW - Zone 3)
Military use (ASW Tactics - Zone 4)
Military use (General operations - Zone 6)
Outer continental shelf lease areas
Ferry routes

Shoreline Not Otherwise Classified	4
Mineral Resources Subject to Burial	3

Sand resource areas

Non-coded Areas	0

All other areas not otherwise classified above

DERIVED MAP DESCRIPTIONS

This section describes the development of the key derived maps used as issues in this study. The key derived maps are:

- Ecological Sensitivity D-2
- Potential for Water Quality Deterioration D-3
- Potential for Spreading of Deposited Materials D-5
- Fisheries Sensitivity D-7
- Coastal Area Sensitivity D-8
- Resources and Uses Sensitivity D-9
- Monitoring and Surveillance Sensitivity D-10

The development of each of these derived maps is traced through the Data Structure Diagram. Rationale for combination of the maps is also provided.

ECOLOGICAL SENSITIVITY D-2

The development of this map which includes the following source and derived maps:

- Benthic System (A) S-1
- Benthic System (B) S-2
- Pelagic System S-3
- Ecological System D-1

This derived map represents conservative estimate of the local impact of disposal of dredged material at any given unit of the map. Historically, the Food and Drug Administration has moved to close fisheries within a 11 kilometer (6 nautical mile) radius of dump sites when monitoring begins to show contamination of local species. Influence halos around existing dump site areas in the form of elevated total organic carbon levels are evident in this order of magnitude (11 km radius). Trace element concentrations around the New York Bight Sewage sludge dump site extended out to comparable distances from deposition areas. A radius of 11 kilometers was used in this study as a conservative impact radius for the ecological system and fisheries analyses.

The map is developed through operations on the ecological system map D-1 which is a representation of relative importance of the biological community throughout the study area. The operation consists of summing the values on map D-1 within a 11 kilometer radius of the grid unit being evaluated. This provides a numerical measure of the biological community both at and in the vicinity of the disposal site, which would be potentially impacted by disposal operations.

As indicated, map D-1 is a representation of the biological community importance. This map combines the benthic realm (S-1, S-2) source maps with the pelagic realm source map (S-3). The maps are combined with a direct weighted overlay procedure. The benthic maps receive a higher relative weight because this realm is more subject to long term effects of spoil deposition. The overlay weightings used provide a 3:1 ratio of importance in favor of the benthic species.

Potential for Water Quality Deterioration Derived Map (D-3)

The development of this map which includes the following source maps:

1) Water Quality (S-4)
2) Water Column Stratification (S-5)
3) Dynamic Characteristics (S-6)
4) Bathymetry (S-7)

Bathymetry and dynamic characteristics are analyzed together to obtain a representation of potentially available flushing volumes. These flushing volume classes are then modified through consideration of stratification with its limiting influences on mixing and circulation. A final modification to the flushing volume classes is applied through consideration of existing water quality conditions. The assimilative capacity of a water mass is a function of its existing contaminant loading; the higher the existing loading, the lower is the capacity to assimilate additional contaminants.

Potential for Spread of Deposited Dredged Materials, Derived Map (D-5)

This map evaluates the containment capability of the potential disposal sites. The analysis includes the following input data:

1) Dynamic Characteristics (S-6)
2) Bathymetry (S-7)
3) Bottom Energy (S-8)
4) Sediment Accumulation (S-9)

The depth of water through which the dredged material must fall is a major variable describing the amount of water entrained into the discharge jet and its subsequent spread on the bottom. Depth ranges representing different entrainment conditions were used to classify water depths. These values were modified in an overlay procedure to consider the added spreading influences of currents as embodied in the dynamic characteristics source map (S-6). The combined maps provide a measure of the extent of the initial spread of the deposited materials.

The sediment accumulation map (S-9) provides only net accumulation overtime because of the nature of the data used in its preparation. With reliance on this map only, situations could exist wherein high accumulation rates are measured but because of very high sediment inputs to the area, significant resuspension and transport could occur without notice. Therefore, the bottom energy map (S-8) was compared with the sediment accumulation map (S-9) to obtain a modified accumulation potential map. Areas with low energy and high accumulation were verified as accumulation areas. Areas with high energy and low accumulation were verified as dispersal locations. Appropriate values were assigned to intermediate combinations.

Derived map D-5 is developed by combining in an overlay procedure the intermediate maps which represent the spreading potential associated with initial deposition and the spreading potential associated with long term resuspension and transport with the emphasis being placed on the long term influences.

Fisheries Sensitivity Derived Map (D-7)

The evaluation of fisheries sensitivity (D-7) is a parallel analysis to that of Ecological Sensitivity (D-2) in that all fisheries within a specified radius of the potential disposal sites are conservatively considered to be impacted. The model used to perform the analysis is identical to that used for map D-2 including the adopted 11 kilometer radius of impact. Justification for the model and radius selection is provided under the discussion of map D-2. The overlay combination of the two components of the fisheries and shellfisheries system (maps S-10 and S-11) is operated on by the model.

Coastal Area Sensitivity Derived Map (D-8)

This derived map evaluates the visual impacts of open water disposal operations. The analysis consists of a use of shoreline proximity model with decaying sensitivity as a function of distance offshore. As such, it is a subjective measure of such impacts as the observability of floatable material and turbid waters. The model operates directly on shoreline data stored in resources and uses map, S-14.

Resources and Uses Sensitivity Derived Map (D-9)

This derived map evaluates the potential impact of open water disposal on non-living resources and legitimate uses of the ocean surface, water column and bottom. The analysis uses an impact model such as the one described for Map D-2, Ecological Sensitivity. All resources and uses within a radius of 5 kilometers from the potential disposal sites are considered to be impacted. The model adds all these values and calculates an average value which is then assigned to the grid unit being evaluated. The data structure diagram shows the schematic development of this map and indicates the scope of the resources and uses considered. Three source maps (S-12, S-13 and S-14) are used for ease of data handling only.

Monitoring and Surveillance Sensivity Deried Map (D-10)

This derived map represents the relative degree of difficulty in achieving an effective monitoring and surveillance program at a potential disposal site. Inputs to the evaluation include:

1) Bathymetry (S-7)
2) Distance from shore (S-14)
3) Potential for spreading of deposited materials (D-5)

Distance from shore is included to represent increasing difficulty of operation for monitoring/surveillance vessels both in terms of weather/seas encountered and in transit times to and from the site. Distance from shore also provides increased incentive and opportunity for short dumping by disposal contractors.

Bathymetry is included to represent the increasing difficulties involved in monitoring water column and near bottom conditions in deep water. Potential for spread of deposited materials is included as a measure of the size of the zone which must be monitored. This derived map translates directly into Issue Map 16, Monitoring and Surveillance Sensitivity.

APPENDIX B-1

INTERVIEWS

APPENDIX B-1

INTERVIEW LIST

ENVIRONMENTAL GROUPS

New York

George Wilde, Marine Environmental Council of Long Island

James Bagg, Suffolk County Council on Environmental Quality

James Tripp, Environmental Defense Fund

Frank Bear, North Folk Environmental Council

Connecticut

Christopher Roosevelt, Oceanic Society

Rhode Island

Trudy Coxe, Save-The-Bay

DREDGING COMPANIES

New Jersey

Michael Reich, Assistant Division Engineer, Great Lakes Dredge and Dock Company, Union.

William McPhillips, Weeks Dredging and Contracting Co., Cranford.

Connecticut

William Malloy, Thames Dredge and Dock Co., New London.

Massachusetts

Robert C. Bolger, Superintendent, North Atlantic Dredging, Division of Perini Construction Co., East Boston,

Alan J. DeBoer, Chief Engineer, North Atlantic Dredging Company

Robert Bolger, Jr., Dredging Manager, North Atlantic Dredging

REGIONAL PLANNING AGENCIES

New York

Dewitt Davies, Principal Planner, Long Island Regional Planning Board

S. Robbins, Senior Environmental Planner, Suffolk County Planning Department

See also: James Bagg, Suffolk County CEQ (listed under Environmental Groups)

Connecticut

Richard Erickson, Executive Director, Southeastern Connecticut Regional Planning Agency

Richard Carpenter, Executive Director, Southwest Regional Planning Agency

LOCAL POLITICAL OFFICIALS

New York

James Lack, New York State Senator, 2nd District

Dr. Robert Sisler, Environmental Commission Advisory Board of Port Jefferson; representing Mayor Harold Sheprow. Also attending: Bill Adam, also a member of the ECAB

Kenneth Butterfield, Supervisor of the Town of Huntington. Statement of Testimony given at the May 3 public meeting.

Robert J. Mrazek, Suffolk County Legislator, 18th District

Connecticut

Michael Pavia, Executive Director of the Environment Protection Board, City of Stanford, representing Mayor Louis Clapes.

Albert Landino, Development Administrator and City Engineer, City of New Haven, representing Mayor Frank Logue.

Donald Sweet, Mayor of Groton.

FISHERMEN AND FISHERMAN'S GROUPS

New York

Richard Miller, Long Island Fisherman's Association

Richard Erpenbeck, Fishers Island Lobsterman's Association

George Doll, lobsterman; Northport, New York

Butler Flower, oysterman; Bayville, Long Island; also present: William R. Haines, General Manager, The Bridgeport and Port Jefferson Steamboat Company.

George Gerhold, The New York Sportfishing Council

Connecticut

J.R. Nelson, Long Island Oyster Farms; New Haven.

John Baker, Aquaculture Division, Connecticut State Department of Agriculture

Christopher Stapefeldt, Connecticut Commercial Fisherman's Association, Wilton.

Kay Williams, lobsterman, Bridgeport, (also present with the Connecticut Commercial Fisherman's Association)

Paul Previty, Southern New England Fisherman's Association, Stonington.

Rhode Island

Leonard Stasiukiewicz and Robert Smith. Point Judith Fisherman's Co-op, Galilee.

SHIPPING COMPANIES

New York

Joseph Akell, Senior Vice President, Chief Planning and Development Officer, Nacthville Industries; Melville.

Connecticut

Byron McCandless, Assistant Vice President and Engineering Manager, New Haven Terminal Inc., New Haven.

Henry St. Laurent, Treasurer, New Haven Terminal Inc.

CONGRESSIONAL REPRESENTATIVES

New York

Jerome Ambro, 3rd Congressional District of New York

Connecticut

Peter Villano, Legislative Assistant to Congressman Robert Giaimo, 3rd Congressional District of Connecticut

Rhode Island

John Riley, Administrative Assistant to Congressman Edward Beard, 2nd Congressional District of Rhode Island

BUSINESS AND TRADE ASSOCIATIONS

New York

James Olsen, Long Island Marine Trade Association

Edward Parthe, Association of Marine Contractors

Gloria Rocchio, Long Island Tourism Commission

Connecticut

Allan Berrien, Connecticut Marine Trade Association

STATE ENVIRONMENTAL AND COASTAL ZONE AGENCIES

New York

Gordon Colvin, Regional Supervisor of Environmental Analysis, New York State Department of Environmental Conservation

Randolph Stelle, Chairman, New York Department of Environmental Conservation

James Morton, Coastal Management Unit of New York Department of State

Connecticut

Robert Leach, Staff Engineer, Coastal Area Management Section, Connecticut Department of Environmental Protection

Dennis Cunningham, Connecticut Department of Environmental Protection

Rhode Island

John Lyon, Chairman and Director, Coastal Resource Management Council of the State of Rhode Island

Edward Wood, Director, Rhode Island Department of Environmental Management

APPENDIX B-2

AREAS OF CONCERN AND ISSUES RELATED TO OPEN WATER DISPOSAL

Dames & Moore conducted a number of interviews with various interest groups, concerned individuals and public agencies in the Rhode Island, Connecticut and Long Island areas. The purposes of the interviews were several: 1) to acquaint Dames & Moore with the issues and concerns perceived as significant by groups either potentially affected by or with jurisdiction over the issue of dredge spoil disposal in Long Island Sound, and 2) to acquaint Dames & Moore with other individuals, groups or agencies actively involved in the above issue. Interviews were selected to represent major private and public groups that would be affected by any decision concerning the selection of new dredge spoil disposal sites in Long Island Sound. The list of interviewees appears in Appendix A-1.

The following summary of issues addressed by interest groups lists the significant issues, impacts and concerns as they were identified by each major interest group.

Environmental Groups

Their primary concern was the potential uptake of toxic materials (heavy metals) into the food chain. They were also concerned over the dumping of highly organic spoil with BOD that could create oxygen-depleted zones. They were very aware of the estuarine nature of Long Island Sound and its fragile ecosystem.

These groups were knowledgeable about the New London litigation, and worried that the Corps

a) was not addressing the issue of dredge spoil disposal in the Long Island area in a comprehensive manner (not considering alternative disposal techniques) and/or

b) would not be able to meet the December 31 deadline.

They suggested a classification system for dredge spoil: Class I - acceptable, Class II - case-by-case basis and Class III - clearly unacceptable. The classification would be done by bioassays, and disposal sites would be selected on a dispersal or containment basis. Different types of spoil would be dumped at sites with physical characteristics suited for that type of spoil, so that environmental impact is minimized.

Two groups were in favor of the Stamford-New London experiment as an experiment in handling toxic spoil.

Many of the groups on Long Island were opposed to any dredging disposal in the Sound, regardless of the type of material, unless they could be guaranteed that there would be little or no adverse environmental impact.

Dredging Companies

Dredging companies did not believe continental shelf dumping was an economically viable option, and cited several problems:

a) Productivity of dredges would fall off due to transit time and loss of hauling due to weather.

b) Extra capital required (covered barges, ocean going tugs, etc.) would not be difficult to justify economically due to low volume of dredging in New England.

c) Some felt such a requirement to dump at the shelf would give business to Great Lakes Dredge and Dock Company as they are the only ones large enough to compete with the Corps.

Short dumping was noted as an occasional problem, particularly during the night, or in fog or heavy weather.

Sound Dredging Inc. and the Thames Dredge & Dock Co. were the only known small, local dredge outfits operating along the Connecticut coast. Longer hauling distance and the higher costs of doing business had already forced most local operators out of business. While the Corps has expressed concern over the future adverse impacts on small independent dredging operators of selecting new sites further from shore, these impacts are already being felt by these small operators.

Dredging companies commented that in general, dredging work in Long Island Sound is low enough in volume, and average job is of a size (due to small harbors) that the use of large equipment capable of capturing economies of scale is generally not feasible. Mobilization and demobilization costs thus become a higher percentage of total job costs, and it is not economically rational to keep large pieces of dredging equipment on standby in Long Island Sound waters.

Several comments were received that spoil from western Long Island Sound could be taken down the East River to the New York Bight, as this area is already being dumped in.

Regional Planning Agencies

Connecticut

Regional planning agencies in Connecticut had little, if any, direct involvement, knowledge or experience with the issue of dredge disposal in Long Island Sound. Their greatest concern was for the potential impact of toxic or organic spoils on the Sound's water quality and marine resources. They were very aware of the economic importance of industries, installations, and recreational boating interests that require maintenance dredging to help maintain their economic viability. Connecticut is very dependent upon shipments of home heating oil via Long Island Sound.

Several respondents mentioned the desirability (economic efficiency and minimizing of potential adverse environmental impacts) of designating several Connecticut ports as regional ports for the receipt of oil and other goods. This would lessen the need to keep many of the smaller harbors dredged to allow passage of commercial ships, and would confine adverse environmental impacts to a smaller number of harbors.

New York

The Long Island Regional Planning Board has been active in planning with respect to Long Island Sound. They have sponsored a number of studies concerning the Long Island marine environment, including one of dredging. Some of their specific concerns about the disposal of dredged material in the Sound were:

a) They (Long Island Regional Planning Board; residents on the Island) have had little or no input into the Bi-State Dredging Plan.

b) They suggest a controlled dredging approach, tailoring the disposal of different types of material to sites with characteristics (depth, current, and so on) best suited to minimize the environmental impact.

c) They are concerned with impacts of organic compounds; PCB's, phosphates, nitrates, and others.

d) They suggest the use of different criteria in selecting sites to receive organic, as differentiated from toxic spoils.

e) They mentioned a need to conduct research in the area of the long range impacts of sedimentation in central Long Island Sound (i.e., how much would disposal add to this problem).

f) They saw a need for the regional consolidation of shipping facilities, and mentioned Port Jefferson.

The Long Island Regional Planning Board, Nassau-Suffolk Regional Marine Resources Council and the Suffolk County Planning Commission all are on record as opposing the Stamford-New Haven dredging project.

Local Political Officials

Connecticut - Rhode Island

Local political officials in Connecticut and Rhode Island stressed that dredging was necessary to help maintain the economic viability of harbor and port facilities, as well as to maintain property values of waterfront parcels. Their general position was that open water disposal should be done if the perceived adverse environmental impacts are less than the losses in economic activities that would occur if dredging did not take place. The disposal method needs to be economically viable, at lowest cost.

In most cases, officials felt land disposal would encounter a great deal of opposition. They perceived the major potential adverse environmental impacts from open water disposal as water quality impacts and the fouling of beaches.

Long Island

Political officials at all levels (Congressmen, State Legislators and local officials) are opposed to any dumping of dredge spoil in Long Island Sound. They are particularly opposed to toxic or other highly contaminated dredge spoils. Their major complaint was that they have been through this hearing process in the past and it makes no difference, that the Corps has already decided that there will be dumping in the Sound. Political officials cite several points:

a) refusal of the Corps to adopt EPA Ocean Dumping Criteria

b) lack of Corps knowledge about potential effects of toxic spoil on the marine ecosystem and potential for uptake into the food chain.

c) "...the state-of-the-art has not been sufficiently developed to insure any safe method of controlling hazardous dumping within the confines of the Sound." State Senator James Lack

d) inadequate consideration of alternatives to dumping in the Sound's waters.

Several respondents felt dredging could increase the potential for salt water intrusion into the aquifer supplying their town's drinking water.

Fishermen and Fishermen's Groups

Fishermen and fishermen's groups are opposed to open water dumping of dredge spoil, regardless of type of spoil or dump location. They see the impacts on fishing as including:

a) Sedimentation of spawning areas and suitable habitat for shellfish species.

b) Destruction of spawning areas results in longer term impacts that are not immediately apparent, in terms of future reduced catches.

c) Loss of trawling rigs or nets on short dumps. Nets snag on timbers and rocks.

The fishermen had no evidence that in some instances dredging resulted in making fishing grounds more productive. The oystermen do not want dredging between July and mid-September as potential for uptake of toxic materials by the pelagic state of newly spawned oysters is greatest. Sedimentation of oyster beds and decline in water quality is their greatest worry.

Fishermen feel ocean dumping occurs because they were not politically powerful enough to prevent open water dumping. Fishermen feel that they receive the full brunt of the adverse economic impacts of open water disposal, while the rest of society receives the economic benefit of maintaining navigable waterways. They feel that Block Island Sound and the water around Fisher's Island should be ruled out as potential disposal areas because they are too valuable as fishing areas, both commercial and recreational. They are opposed to deep water dumping as there is a viable deep water fishery for finfish and shellfish that would be adversely affected.

The long-term impacts of dredge disposal on fishing, particularly spawning as impacted by an increase in water column turbidity and sedimentation effects, are not well defined by present scientific knowledge. Potential consequences of dumping dredge spoil in deep or continental shelf waters is largely unknown.

"No sites in Block Island Sound, adjacent water south of Montauk out to the 40 fathom line should be considered as a potential dumping site. This area is too valuable as a commercial fishery to the mid-Atlantic area and southern New England." Richard Miller, Long Island Fishermen's Association.

Shipping Companies

Shipping companies need to dredge to maintain the economic viability and competitiveness of their operations. The cost of maintenance dredging has risen as the number of disposal areas has diminished and the cost of hauling has increased. Further, the regulatory process inhibits them at times when a dredge is in the area and they need to be dredged. They cannot afford to wait to receive their dumping permits in such cases. Further, New England and Long Island are dependent upon oil shipped by tanker. If harbors are not kept to proper depths, ships can only come in partially loaded and the unit cost of all waterborne goods rises.

Offloading oil at offshore facilities increases spill potential, and thus pollution. The idea of consolidating shipping facilities in one port was mentioned. Specifically, Port Jefferson was suggested for upgrading to a major port on Long Island Sound, capable of receiving oil tankers requiring a 35' draft.

Congressional Representatives

Connecticut and Rhode Island

Congressional representatives from Connecticut and Rhode Island believe that dredging is an economically necessary activity to maintain navigable waterways. However, open water disposal should be evaluated in terms of its potential adverse environmental effects so that all are fully aware of the tradeoffs involved. Disposal methods and sites should be selected to minimize potential adverse environmental effects. They were particularly concerned with the economic impacts on the commercial finfishing and shellfishing industries in the Sound. They balanced this economic impact against the need to maintain depth in harbors to allow oil tankers to come and go with full loads. This keeps unit costs of oil lower.

New York and Long Island

Congressmen from Long Island are opposed to the dumping of dredge spoil in Long Island Sound, particularly when it benefits other areas such as Connecticut. A moratorium on present dumping was suggested until assurances could be given that no long term, irreversible damage to the Sound's ecosystem was being caused. Several congressmen expressed concern over the potential impact of dumping toxic spoil in the Sound, the potential impact on valuable fisheries, and uptake into the food chain. Doubts were registered about the efficacy of the current capping procedure being employed at the New Haven dump site, as it was being used without the Corps knowing whether or not it was an effective method for preventing the dispersal of toxic spoil materials into the marine environment.

The fact that the Corps has not adopted the EPA Ocean Dumping criteria for the spoil being dumped into the Sound was noted by Congressman Ambro.

Business and Trade Associations

Marina owners and marine contractors depend on dredging as they must be able to dredge out their slips to maintain depth, which in turn allows them to maintain dockage rental rates, and hence, revenues. Marina owners need nearby dredge disposal sites in the open water to keep down the cost of their maintenance dredging. By cutting down on the number of disposal sites in the Sound transport costs have increased and so have the unit costs of dredging. The Connecticut Marine Trades Association feels the increasing cost of dredging has been a contributing factor in the decline in the economic viability of some marinas along the Connecticut coast. They also felt that the recreational boating industry is more important economically in both Connecticut and Long Island than is the commerical fishing industry. (They could not document this, but said they would be able to in the near future). They feel that the environmental impacts associated with the open water disposal of most types of material (excluding highly toxic spoils) are small enough in magnitude that open water disposal should continue. Dredging is an economically necessary activity to maintain the viability of their enterprises, and given the known environmental effects, open water disposal is currently the most cost effective way of doing so. The concept of zoning Long Island Sound was presented; some areas should be kept pristine, other areas already heavily used can be disposal areas for dredge spoil.

Tourism and the commerical fishing industry are of primary economic importance to the Long Island economy. Dredging policies having an adverse effect on either industry would be widely felt.

Respondents recognized that the need for dredging by the various marinas and recreational boating industry did work contrary to the desires of the commercial fishing people who would prefer not to have any ocean dumping. However, nearby open water or Long Island Sound dumping sites are the cheapest means for disposing of dredge spoil for marinas and industrial concerns needing maintenance dredging. The current use of only three sites in the Sound for the disposal of dredge spoil has increased the cost of dredging.

State Environmental and Coastal Zone Management Agencies

Rhode Island

The major concern in Rhode Island was having a disposal site within easy reach of Providence harbor. The need for an (economically) accessible dump site was noted because of a backlog of dredging there. Environmental impacts of open water disposal of clean fill are low enough so as to make open water disposal an acceptable means of disposing of dredge spoil. Alternative uses of dredge spoil (beach fill, salt marsh creation, containerization, upland disposal) should be encouraged. However, current Corps interpretation of regulations do not encourage alternative uses. The use of Brenton Reef as a disposal site was recommended.

Connecticut

The major concern in Connecticut was that Dames & Moore's final report be consistent with Connecticut's and New York's Bi-State Interim Dredging plan. It is felt that the disposal of dredge spoil in the Sound has had only a minor contribution to the decline in water quality of the Sound.

They feel there is a need for a western Long Island site, and that it will be acceptable to the public if properly presented in a viable management scheme. The scheme would have to explicitly include monitoring. Such a site would help mitigate current adverse economic effects on small coastal uses such as marinas that require frequent maintenance dredging. Land disposal is not a viable alternative. Also, an ongoing public participation component must be explicitly included, as it will give the plan additional credibility and will help acquaint public with the environmental and economic tradeoffs involved.

Their reading of environmental literature indicates that water column impacts are minimal, and that disposal in areas where the water quality has already been adversely affected may be advantageous.

New York

State environmental and coastal zone management agencies from the State of New York emphasized compatibility of Dames & Moore's report with Connecticut and New York's Bi-State Interim Dredging Plan. This includes consistency with New York's Dredging Sub Plan (done by the Long Island Regional Planning Board for Coastal Area Management). State agency personnel recognize the need to work closely with the New England Division and New York District of the Corps. (The dredging subcommittee of the New England River Basins Commission does not provide close enough coordination within the Corps.). A major concern was with toxic spoil (Class III materials in the Bi-State Plan). Resolution and resuspension of contaminants is an issue as well as the potential for uptake into the food chain.

Land disposal for very toxic materials should be considered. The scarcity of coastal land suitable for disposal of such material makes it feasible to consider disposal of only the most toxic spoils.

Monitoring of disposal sites was suggested as a key component to assessing environmental impacts. A disposal strategy taking into consideration site characteristics (dispersal vs. containment) and types of material is preferable, and consistent with the Bi-State Plan.

APPENDIX C

SCOPING MEETINGS

APPENDIX C-1

SIGNIFICANT ISSUES RAISED AT SCOPING MEETINGS

To be treated in depth in CEIS:

Boundaries of Study Area	Management Plan
Capping	Mining of Sand
Coastal Area Management Program	Navigation
Costs	Oysters
Dredged Material	Recreational Boating
Dredging Needs	Shellfish Contamination
Employment	Site Selection
Fisheries	Studies by Others
Health Effects	Water Quality
Long Island Sound	

Boundaries of Study Area

- Discuss rationale for selecting boundaries
- Eastern boundary — well used for fisheries.
- Continental Slope — intense activity area, National Marine Fisheries Service concerns; consider entire slope vs. limit to 100 fathoms, economic and technical feasibility of dumping so far out; compare nearshore vs. offshore environments.

Capping

- Sources of capping material; stability of capping experiment method?
- Monitoring, enforcement, controls.
- Capping is unproven.
- Effect of time lapse between dumping and capping.
- If not successful can contamination be stopped?

Coastal Area Management Program — State of Connecticut

- Balance between boating and fisheries.

Costs

- Consider costs to fisheries, transport costs, costs to small operators.
- Consider all costs, not just economics.
- Economic impact to boating and commerce if no Long Island Sound disposal.
- Long term health costs.

Dredged Material

- Sediment Classification and Mapping — analysis of existing sediment data, pollutants, toxicity, inventory discharges into receiving waters (EPA data).
- Test procedures — discuss suitability and reliability of various tests: elutriate, bulk sediment, bioassay, bioaccumulation

Dredging Needs

- Consider authorized vs. needed channel depths to minimize dredging; long term transportation/harbor use planning.
- Norwalk abatement committee; Oil spill risks with inadequate dredging — alternative is increased trucking.

Employment

- Onshore and offshore.

Fisheries

- Lobsters — Norwalk presently productive; impact at existing dump sites.
- Identify areas dragged and barren areas.
- Coordinate with Connecticut Commercial Fishermen's Association.
- Dredge at times of lower water temperatures to minimize impacts on fish.
- Sportfisheries — pollutant uptake; catch increasing, dumping risks impacting resources, waters needed for food and, therefore, should preclude dumping.

Health Effects

- Monitoring plan for bioaccumulation.
- Evaluate potential for long term health effects; contingency plans in event of contamination/public health hazard.

Long Island Sound

- North Shore of Long Island not given sufficient weight in past.
- Western Long Island Sound most fragile; 3 knot tide off Eaton's Neck, 1 knot at slack water; unique ecological area; opposition to regional dump sites within Long Island Sound (impacts on fisheries, recreation; state of the art lacking regarding monitoring and controls; stability of capping; heavy metals; public health and welfare).
- Develop plan for terminating of all Long Island Sound dumping till assurances available.
- Use Ocean Dumping Criteria in Sound.
- Western Long Island Sound data — Stone & Webster December 1971, Adelpi University proposed study.
- Model the Sound dynamically — physical oceanography, past/present dumping, ecological sensitivity — prior to any long range dumping plan.
- Long term effects of spoil erosion.
- Consider entire water column.
- Answer past technical questions — metals exceed limits, environmental effects.
- End all dumping in Long Island Sound — long term effects are unkown.

Management Plan

- o Detailed studies before dumping;
- o Site allocation scheme, clean vs. toxic material, spoils/sites — suitability criteria.
- o Monitoring; testing; safeguards; controls; monitoring plan for bioaccumulation.
- o Jurisdictional requirements, Ocean Dumping Act (Section 103), Clean Water Act (Section 404).
- o "Short dumps" relative to long transport routes and resultant health hazards, consider auto-location recorders.
- o Testing should precede dumping.
- o Treat material before dumping.
- o Don't dump polluted materials.
- o Long range monitoring needed.

Mining of Sand

- o Resultant holes provide sites with minimum capping requirements but disposal there would preclude future mining.

Navigation

- o Disposal piles are obstructions to dragging.

Oysters

- o Estuaries and surrounding tidal marshes critical; larval — heavy metal uptake, silver sensitivity.
- o Norwalk Harbor oyster beds.

Recreational Boating

- o Economic need for close dump sites.
- o Reopen historic sites for certain materials.

Shellfish Contamination

- o Identify significant species, habitat, behavior.
- o Pollutant uptake — metals, pesticides, herbicides, PCB's, coliform, hydrocarbons, pathogens not picked up by coliform counts. FDA action levels; filter feeders; uncooked species.
- o Resource uses — food chain; health effects; sanitary controls; agency responsibilities; presently closed areas, conditions for reopening.
- o Monitoring; enforcement; conditions for future closings.
- o Disposal sites — consider deep water dumping in 300' depths.

Site Selection

- o Distribution of sites; regional sites independent of specific projects; site capacity, uses by material type, expected needs.
- o Consider in-water productive uses, sand overlay on muddy sites for oysters, leave undisturbed mounds for lobsters.
- o Site Designation — discuss formal "designation" procedure by EPA.

Studies by Others

- o Coordinate with other studies — EPA, EIS on offshore disposal sites
- o Corps New England Division Contaminant study and Disposal Area
- o Monitoring System (DAMOS).
- o Corps New York District Mitre study on land alternatives.
- o New England River Basins Commission proposed study of land alternatives.
- o TerEco procedural guide for assessing designated EPA ocean dump sites.
- o Stone & Webster report on discharge modification for Long Island Lighting Company.

Water Quality

- o Define water quality, State standards, uses, classification, long term trends, baseline data.
- o Public understanding — what is meant by water quality, how is it monitored, by whom, when is there concern for contamination, safeguards?
- o Nassau County Water Quality — past deterioration, presently improving, shellfish beds.

APPENDIX C-2

OTHER ISSUES

Not significant or treated elsewhere

Alternatives	Oysters
Cost-Benefit Analysis	Regulatory Responsibilities
Cumulative Effects	Surface Runoff into Long Island Sound
Massachusetts Waters	Testing
Mosquito Control	Water Supplies

Alternatives to Open Water Disposal should be detailed in CEIS

The Composite Environmental Impact Statement is one part of a broader continuing effort to develop a Management Plan for disposal of dredged material. A brief review of the status of that effort may be helpful.

Historically, for reasons of economics and availability of sites, open water disposal of dredged material has been the preferred alternative. Environmental considerations were late to arrive on the American scene, chiefly by way of the National Environmental Policy Act in 1969. The interactions of people and their environment are complex and not easily quantified. At this point in time environmental concern are just beginning to assume their necessary role in the assessment and decision making process. Open water disposal continues to be the option most frequently chosen but with increasingly detailed environmental assessments, monitoring, and public participation.

Admittedly the process is a slow one. The state of the art is severely lacking in treatment of alternatives to open water disposal. A goal of the management plan is to bring the knowledge of all feasible alternatives to the same level of detail and then to continue to expand each.

The composite EIS will assess the effects of open water dispoal on a comprehensive regional basis and identify the least environmentally sensitive disposal sites. The "tiering" concept described in the Council on Environmental Quality regulations allows a broad generic treatment of alternatives. Open water disposal, due to its current use, is an issue "ripe for decision" and in need of immediate comprehensive assessment. Subsequent studies, assessments, and impact statements detailing alternatives such as land disposal, shoreline extensions, marsh and island creation, and containerization will be available to the decision makers.

It is important to state at this point that the CEIS will not mandate open water disposal. Normal local, state, and federal regulatory processes will continue to be the route for obtaining the necessary authorizations. The CEIS will be but one more aid available to the decision makers.

Alternatives to open water disposal must be studied and assessed in comparable detail. Such alternatives are chiefly State coastal zone management concerns. The Corps has recommended to the New England River Basins Commission that they serve as a focal point for the states in development of a further EIS to assess these alternatives.

Cost-Benefit analyses on Corps' projects

This is a subject for treatment when assessing a specific Corps of Engineers' dredging project. The CEIS is not project specific.

Cumulative Effects

Should be quantified with regard to toxins, health impacts. The state of the art, including test data, is severely lacking in this regard. The CEIS will necessarily be limited to a discussion of available information and possible future treatment of this subject.

Massachusetts Waters should be included in the Study Area

The study area was chosen as a management ecosystem for EIS development. A separate EIS is planned for Massachusetts and other Rhode Island waters.

Mosquito Control from increased breeding areas should be addressed

This would relate to nearshore marsh creation and land disposal and not to open water disposal being addressed in the CEIS.

Oysters —Estuaries and surrounding tidal marshes critical; cumulative impact of wetland filling

These are subjects related to alternatives to open water disposal and as such would be treated in a very general sense in the EIS except to the extent open water disposal would impact estuaries and their marshes.

Regulatory responbilities — Expand decision making criteria to reduce subjectivity

Regulatory responsibilities will be discussed briefly in the CEIS. It is anticipated that with development of the CEIS and the Management Plan that subjectivity will be reduced in the future.

Burden for disposal should be with community benefiting from dredging

This is an issue to be considered by regulatory agencies in reaching their permit decision. It cannot be answered in an EIS.

Surface runoff should be collected in basins and not allowed to enter Long Island Sound

To the extent that such runoff contributes contaminants to dredged material this subject will be addressed. However, the control of such sources of runoff is subject to local, State, and Federal regulatory agencies and applicable water quality standards.

Testing — Discussion of bioassay procedures; critique of bioassay procedures manual

Some discussion of this subject will be included, but a detailed critique of the manual is not felt to be significant to the CEIS. EPA and the Corps jointly developed the manual after considerable study; undoubtedly it will be carefully reviewed as it is used.

Water Supplies — aquifer contamination

This relates to land disposal alternatives and will not be detailed in the CEIS.